POWER PLANT ENGINEERING

GENERATION - TRANSMISSION - DISTRIBUTION - UTILIZATION

Contents

½ Oz. 262
With the Editors 263
Third World Power Conference
U. S. Industrial Alcohol Co. Builds New Power Plant 264
Pilot Light Lessens Production Losses 269
When Troubles Come with Mechanical Draft. By J. R. Darnell 270
The Spirit of Mr. Goldberg 272
Measuring High Steam Temperatures. By Gustaf A. Gaffert 273
Severe Service 275
Combustion Control. Part XV 276
Seals Against Fluid Pressure. Part I 280
Keep Personnel Problems Away from the Power Plant. By H. S. Knowlton 283
Electron Tubes—Principles and Applications. Part IV 284
A New Method of Wiring Panels and Equipment. By A. E. Anderson 289
Butane—The Complete Fuel. By Harry Sherman 292
Rapid Repair Work Speeds Recovery 293
As One Engineer to Another. By G. F. Wetzel 295
Steam Engines for Industrial Service. Part II. By F. J. Vonachen 297
Fusible Plugs Improved by New Specifications. By C. C. Custer 300
Diesel Locomotive Factory Goes into Operation 302
Midwest Engineering Power Conference 306
High Pressure Pipe Joint of Novel Design 307
Reader's Conference 309
Leak Detector. Silent Switch. Coal Spreader. Electric Motors. Thermometers 313
Coil Winder. Motor Starter. Circuit Breaker. Return System. New Treasurer. Fluid Meters 314
News from the Field 315
For the Engineer's Library 316
Power Plant Construction News 318

Contents of back issues of Power Plant Engineering will be found in Industrial Arts Index on file in Public Libraries.

MAY
1936

Vol. XL., No. 5

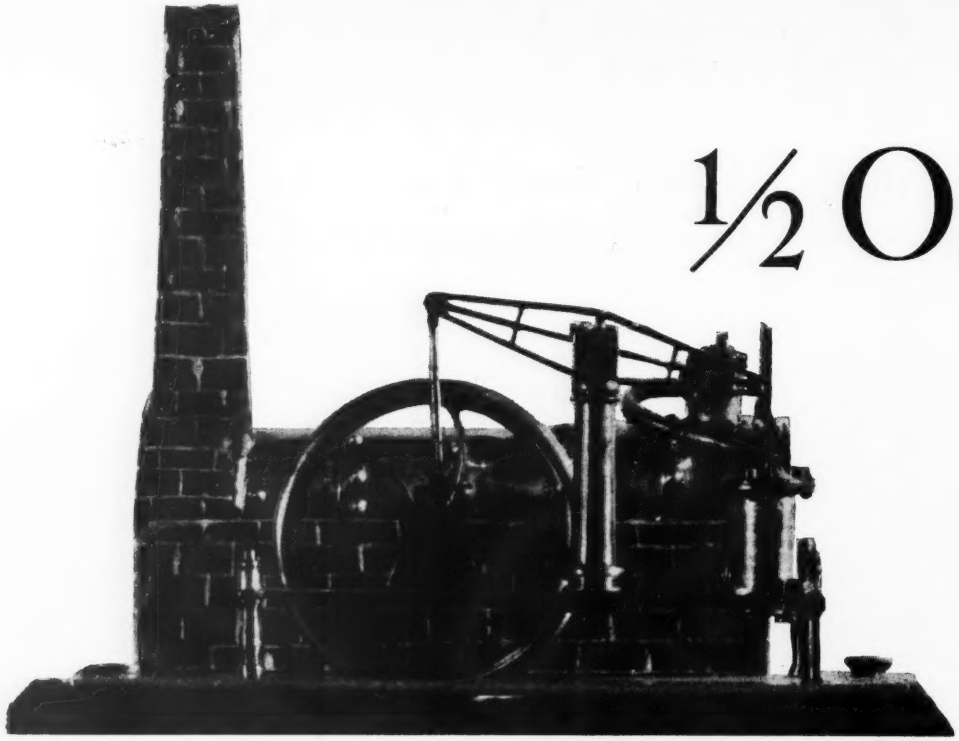
Published on the first of each month, copyright 1936 by the
Technical Publishing Co., 53 W. Jackson Blvd., Chicago.
New York Office, 171 Madison Ave.

EDITORIAL STAFF: ARTHUR L. RICE, Editor. R. E. TURNER, Managing Editor.
A. W. KRAMER, RICHARD H. MORRIS, Associate Editors.

Subscription price. U. S. A. $2.00 a year; other countries, $3.50 a year. Single copy current issue, 25c; other countries, 35c. January issue, U. S. A., 50c; other countries, 60c. Back issues, single copy, U. S. A., 40c; other countries, 50c. January issue, U. S. A., 75c; other countries, 85c.

Member, Associated Business Papers, Audit Bureau of Circulations.
Circulation of this issue, 20,100

½ Oz.



OFFHAND, JUDGING from the photograph shown above one would not say that there was anything remarkable about this engine. It is of a type which is long obsolete and in efficiency it is not to be compared with engines of say, the unaflow type shown in the leading article of this issue. Despite its seeming unimportance, however, this engine will be in operating condition long after the engines in the U. S. Industrial Alcohol Co. plant have been scrapped and this implies no criticism of those units. As a matter of fact this engine has been in existence since 1849 and it is in as perfect operating condition today as it was the day it was built.

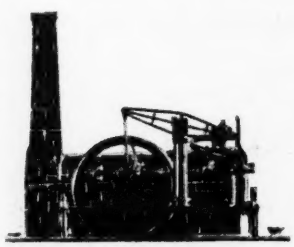
Incredible as it may seem, the photograph shown above, is an enlargement of the actual machine, for this engine is the smallest steam engine ever constructed to run under its own power. It is made of gold and silver and weighs less than one half ounce! Yet it runs on steam and develops a maximum speed of 3000 r.p.m. The actual size of the engine is shown below.

This little engine which is on display in the museum of the Franklin Institute in Philadelphia was built in 1849 by a boy, Cyrus Chambers, Jr., who was only 16 years old at the time. He built it from two of his mother's gold and silver teaspoons. It is the smallest steam engine which ever ran under its own power and was displayed at the Centennial Exposition of 1876 in direct contrast with the great Corliss engine which was the most powerful engine built up to that time. With only a $\frac{1}{16}$ in. steam cylinder and a $\frac{3}{16}$ in. stroke, its total weight is less than ½ ounce.

Of no practical value, perhaps, this little engine nevertheless is well worthy of our admiration. Fine workmanship is always a quality to be admired and when it is coupled with youthful skill as it is in this particular instance it becomes doubly interesting.

Speaking of fine workmanship, we should like to direct attention to the ingenious methods employed in wiring modern switchboards as described in the article on page 289. Electrical switchboards have undergone great changes both in form as well as in materials used during the past decade or two, but few of the improvements made are quite as "clever" as the method of wiring which has been evolved during recent years. The idea of completing practically the entire wiring installation independent of the panel itself was an audacious one but as pointed out in the article by Mr. Anderson, one not impossible of successful achievement.

Another article to which we direct particular attention is the article by Mr. Darnell on Mechanical Draft. When a boiler installation refuses to function as it should or when it does not meet the guaranteed ratings it is easy to blame the induced draft fans. As Mr. Darnell shows, however, induced draft fans are highly developed mechanisms which usually meet specified requirements, and in the majority of instances when trouble is encountered it is necessary to look for the cause elsewhere. The cases which the author describes are extremely interesting and indicate the need for careful consideration of all conditions in the design of any power plant. Mr. Darnell has had many years of experience in the practical application of draft equipment and when he writes about fans, he "knows his stuff."



WITH THE EDITORS

The Third World Power Conference

THE FORTHCOMING Third World Power Conference which is scheduled to be held at Washington, D. C., in September, is to differ materially from the previous power conferences in that it is to be devoted almost entirely to the more fundamental aspects of power development rather than to the purely technical considerations which have governed these meetings in the past. This is encouraging, for it is in this direction that the most serious problems of future power development are to be found.

In the past, questions of power development have been concerned almost entirely with technical considerations; with methods of producing power economically and in quantities sufficient to satisfy the increasing demands of industry and the public, with questions of design of plants and equipmet and of the utilization of fuel and water power resources. This was natural since the industry was young—it still is, of course—and a technique had to be developed. There are still innumerable technical problems awaiting solution today and interest in this direction is as great or greater than ever, but the technique of attacking these problems is well in hand. Modern scientific methods and engineering resources are entirely adequate to cope with any technological considerations that may arise regarding power. Power, furthermore, can be produced in almost any quantities desired.

It is this latter element that has complicated the situation—the very abundance of available energy. As late as 1870 the power availability in this country amounted to only one fifth of a horsepower per capita. Today, we live in a world of 25 horsepower, or even up to a hundred horsepower per capita with a population four or five times as great as it was a century ago.

This enormous increase in the availability of energy, while it has brought many advantages, has also complicated matters. We live in a world dynamically different from that of our grandfathers, indeed the difference between our world and that of our grandfathers is greater than the difference between the world of our grandfathers and the world of Moses. This is a world of railroads, automobiles, airplanes, telephones, refrigerators, electric lights, radios, movies, anti-toxins, textile mills, photocells, etc.—all instruments for the elaboration of power. They take energy, do work and make life easy, and what is not so generally understood, complicate our lives.

For we have come into this "age of power" with a culture, a philosophy, an outlook based largely upon an agrarian civilization—a civilization based upon an economy of scarcity. Today, because of power, we are confronted with the necessity of facing an economy of abundance, and we find ourselves confused. We have suddenly come into a 100 horsepower world with industrial, social and mental habits adjusted to a one horsepower world.

In the world of our grandfathers, a man with a scoop working hard, eight to ten hours a day, could shovel say 12 to 15 tons of coal or earth, moving it a few feet. Today that same man, standing at the controls of the world's largest electric shovel can move five times that amount in less than a minute and, furthermore, lift it to a height of 70 feet! With this shovel, this one man does the work of some 20,000 men in our grandfathers' day.

This is startling and remarkable, of course, and is as it should be for the purpose of a machine is to save labor, but it raises certain questions. How much shall we pay the man operating the shovel? How much should the owner of the shovel receive? How much shall the power company charge for the power delivered to the machine? And who shall receive the profits made in the sale of this power? What about the 19,999 men displaced by the enormous productive capacity of the shovel? What shall they do? Who shall own the coal which this shovel unearths in the case of strip mining?

These and a thousand related questions rise from the development of this shovel. Offhand, some of them do not seem to be related to the general subject of power, but fundamentally, power is at the basis of all of them. The almost unlimited availability of power has revolutionized our whole scheme of living. The job that formerly would take ten hours to do is being performed in twenty minutes and the man performing this job in twenty minutes is certainly not going to receive ten hours pay. In the past we called workers factory "hands." We were hiring hands, not human beings. because, symbolically speaking, we wanted hands to exert force. Today all this force is applied electrically, not only applied but, in many instances, guided and controlled electrically.

In other words, what we have been trying to point out here is that in any consideration of power these days we are confronted with certain factors outside of the power field and unless we are familiar with these basic factors of our civilization we can never hope to attain a proper understanding of the problem as a whole. The question of power today is inevitably linked with questions of social control, conservation of resources, political and economic organization, human relations and many other similar factors.

For these reasons it is essential that we should consider power in its social sense and endeavor by intelligent action and study to arrive at solutions of the problem which shall be for the good of mankind. For these problems are real and they can never be solved by ignoring them or trust in *laissez-faire* policies.

It is encouraging, therefore, that the American National Committee has selected this aspect of the power problem as the subject for discussion at the conference. These discussions should be of great interest because for the first time power will be considered on a world wide basis from this angle. It is intended that the conference shall appeal to the layman as well as the engineer by dealing with the national power economy in terms of an appraisal of the economic and social consequences of what the engineer has done. This is an intelligent attitude for power has become a factor so vital, so basic in our civilization that it can no longer be said to be the concern of any one group.

U. S. Industrial Alcohol Co. Builds New Power Plant

New Power Plant at Newark, N. J., built entirely of steel and glass. This Plant furnishes high pressure and exhaust steam and electricity to the Alcohol plant. Electric Power is generated by vertical Unaflow engine driven alternators

THE U. S. INDUSTRIAL ALCOHOL CO. recently completed the construction of a new power plant at their alcohol plant in Newark, N. J. This plant, which now supplies all the steam, water and electric power required by the Newark plant, while not a large plant is, nevertheless, very complete and constitutes an excellent example of modern small plant design. It was constructed during the summer of 1935 and went into operation in the fall. Thomas E. Murray, Inc., of New York were the designing engineers.

It consists, essentially, of a boiler plant with two 394 hp. stoker-fired boilers and two 3-cylinder vertical unaflow engine driven alternators together with all necessary auxiliaries. The engines are non-condensing units operating against a back pressure of 10 lb. Exhaust steam from these engines as well as from certain auxiliaries, such as the boiler feed pump, is used in the still house and, of course, also for heating feed water.

Plant Built of Steel and Glass

Architecturally, the plant is quite interesting. The entire building above the foundation is of steel and glass. This feature extends even to the partition between the boiler and engine room; instead of the usual solid wall, this is a steel frame glass partition. As a result of this form of construction, the entire plant is unusually light.

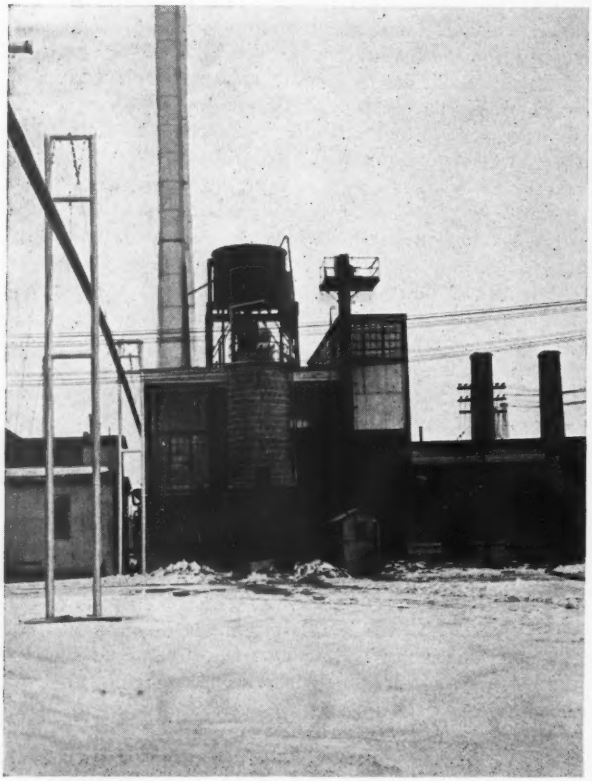


Fig. 1. The plant is built of glass and steel with a 150 ft. self-supporting steel stack set on the building steel

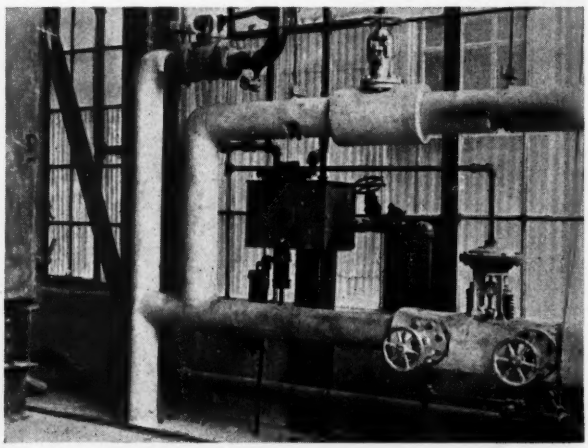


Fig. 2. Combustion is automatically controlled from the steam pressure

The general arrangement is shown in the plan and elevation in Figs. 8 and 10 respectively. As can be seen, there is practically no basement, except for the small room underneath the rear of the boiler room where the induced draft fan is located. The reason for locating the induced draft fan at this point is a consequence of the arrangement of the economizer. The plant is provided with a single return bend economizer arranged to serve either boiler. This economizer is placed in a vertical position at the rear of the boilers.

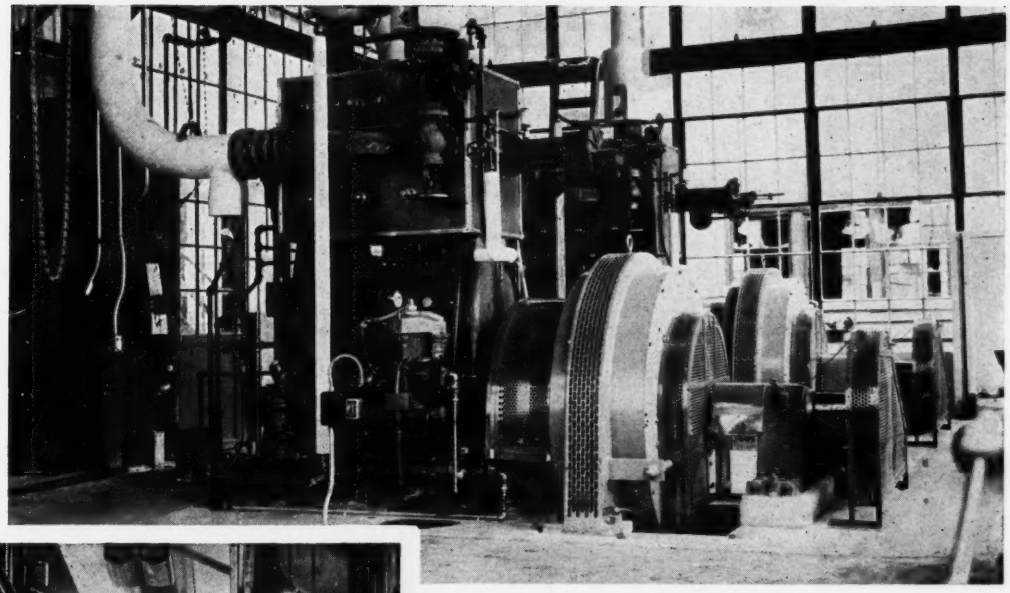


Fig. 4. The two 3 cylinder vertical unaflow engine driven generators

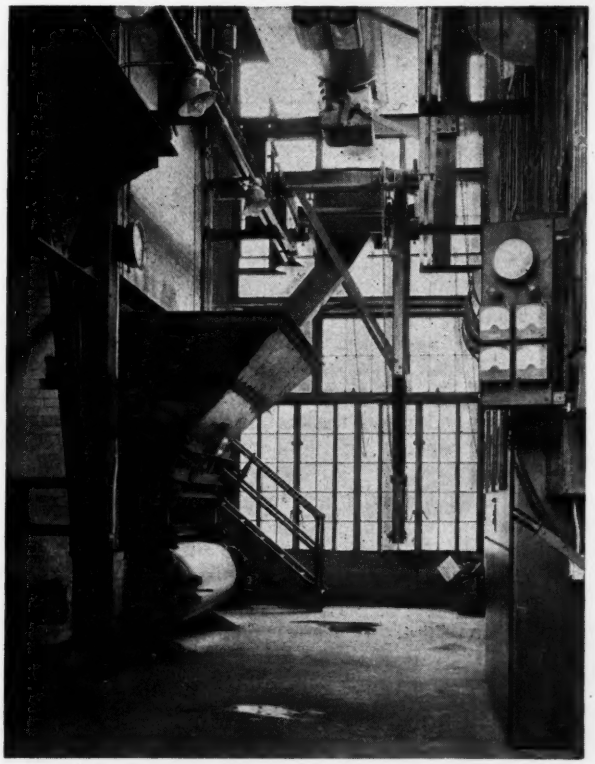


Fig. 3. A view in the boiler room showing the weigh larry and location of the boiler meter panel

Flue gases enter the economizer at the top from either or both boilers and are drawn through it by the single induced draft fan below. The fan discharges directly into the stack through a vertical section of breeching alongside of the economizer. By-pass ducts and dampers are provided so that the economizer and induced draft fan can be by-passed, and the gases discharged directly to the stack. The stack is of steel, unlined and self supporting, 5 ft. inside diameter and 150 ft. high. It is mounted on the building steel.

As will be noted, the coal bunker is located in the center of the plant directly above the firing aisle which is also the main operating position. The electrical switchboard and the boiler control board are placed side by side in the partition separating the boiler and engine room, facing the boilers so that a single operator has complete supervision of the entire plant.

The engine room is simple, the two generating units being placed side by side at one end of the room with provision for another unit. The plant is built on swampy ground, on piles, and the jelly-like characteristic of this soil makes the building susceptible to vibration. The vertical engines contribute favorably to the reduction of vibration.

Since the boiler control and electrical control panels are set in the partition between the boiler and engine rooms, the rear equipment of these panels is exposed to and therefore easily accessible from the engine room. While this does not contribute favorably to the appearance of the engine room, in an industrial plant of this kind this fact is not of great importance and is more than compensated for by the ease of inspection.

All piping in this system has been welded by the multipass Aircowelding method, mechanical joints being employed only for the attachment of equipment and valves to the lines. The welding was performed in accordance with the new American Standards Association Pressure Piping Code, 1935 Tentative Standards. All welding operators were required to pass the qualification tests set forth in this code. The completed welded lines were tested hydrostatically at 1½ times normal working pressure and subjected to blows from a 5 pound hammer. Under this test no leaks or other signs of failure developed. Welding operator qualification, inspection and final testing of the welds were under the supervision of the Applied Engineering Department of Air Reduction Sales Co.

Anthracite coal of approximately 12,000 B.t.u. per lb. is used. This is delivered by railroad car and is carried to the overhead bunkers by means of a simple coal handling system consisting of a track hopper,

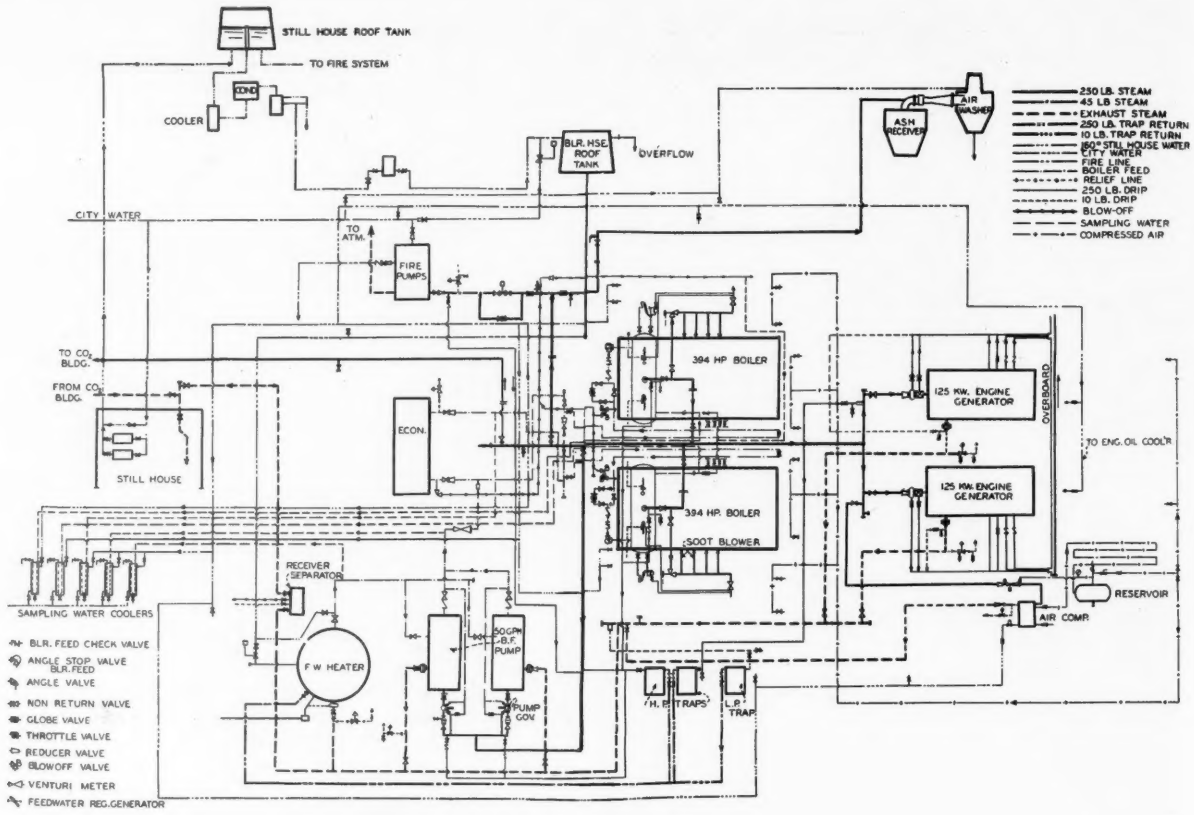


Fig. 5. Flow diagram of the plant

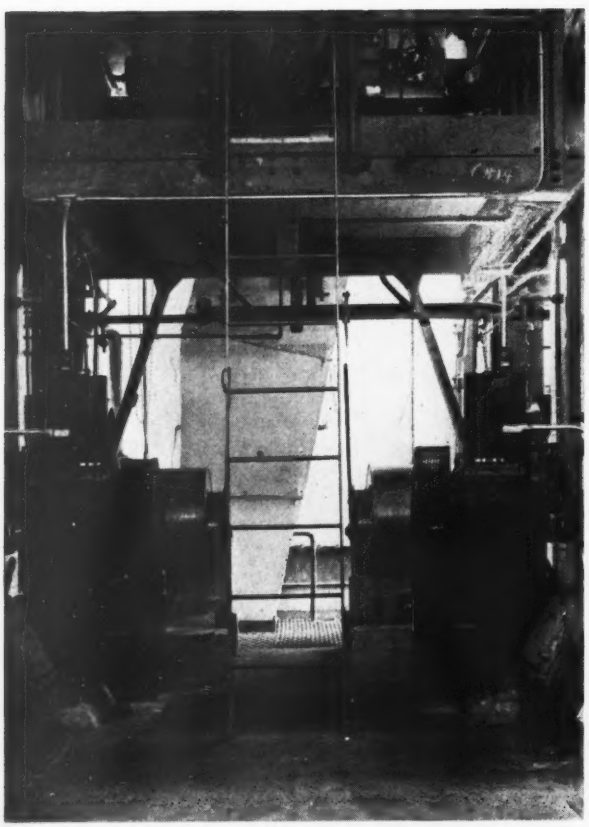


Fig. 6. View between the boilers showing stoker drives

apron conveyor, bucket elevator and scraper conveyor. The latter runs the full length of the overhead bunkers and is enclosed in a steel and glass monitor on the roof of the building. The coal handling equipment is driven by induction motors arranged with interlocks to insure proper sequence of operation in starting and stopping.

In the boiler room a weigh larry equipped with an automatic coal scale is used to deliver coal to the stoker hoppers.

Ash is carried from the ash pits to a 30 t. vitrified tile ash storage bin by means of a pneumatic ash conveyor. The ash storage bin is mounted on a steel structure just outside of the building as shown in the photographs.

Stirling Boilers with Chain Grate Stokers

The boilers are 394 hp. Babcock and Wilcox, type H, class IV Stirling units designed for 275 lb. gage pressure and capable of supplying 23,000 lb. per hr. maximum. There are three drum boilers with 323—3¼ in. tubes, baffled so as to produce three passes, and provided with a Detrick flat suspended arch.

They are fired by Combustion Engineering Co. "Coxe" chain grate stokers having grate surfaces of 7 by 14 ft. and driven through Reeves variable speed transmissions by General Electric 1 hp. motors.

Forced draft is supplied by two American Blower fans, one for each boiler. These units are placed behind the boilers and each discharges directly into the wind boxes of the stoker. The fans are driven by constant speed motors.

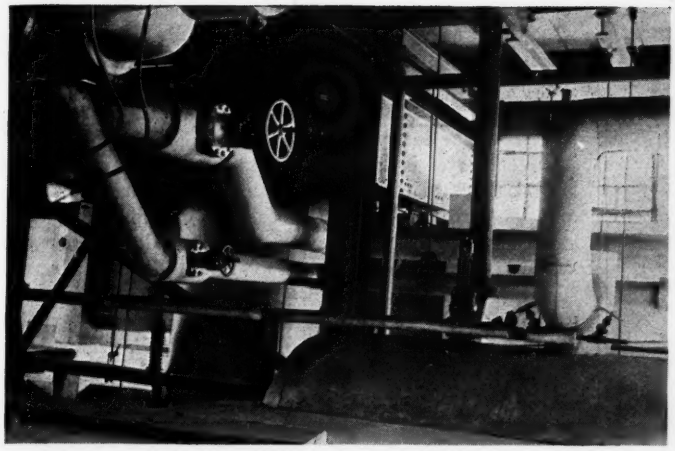


Fig. 7. Looking across the top of one of the boilers

Combustion is controlled by a Smoot combustion control system, arranged with regulators to handle stack or economizer dampers and with one regulator to handle the forced draft fan dampers and stoker drives.

The boiler instrument panel is placed facing the boilers and contains two, 7 element multipointer draft gages, each measuring the pressure in each of the six wind boxes as well as the furnace draft; one two element multipointer draft gage for the economizer; two boiler meters, one for each boiler, measuring steam flow, air flow, pressure and temperature; one fluid

Fig. 9. The scraper conveyor over the coal bunker

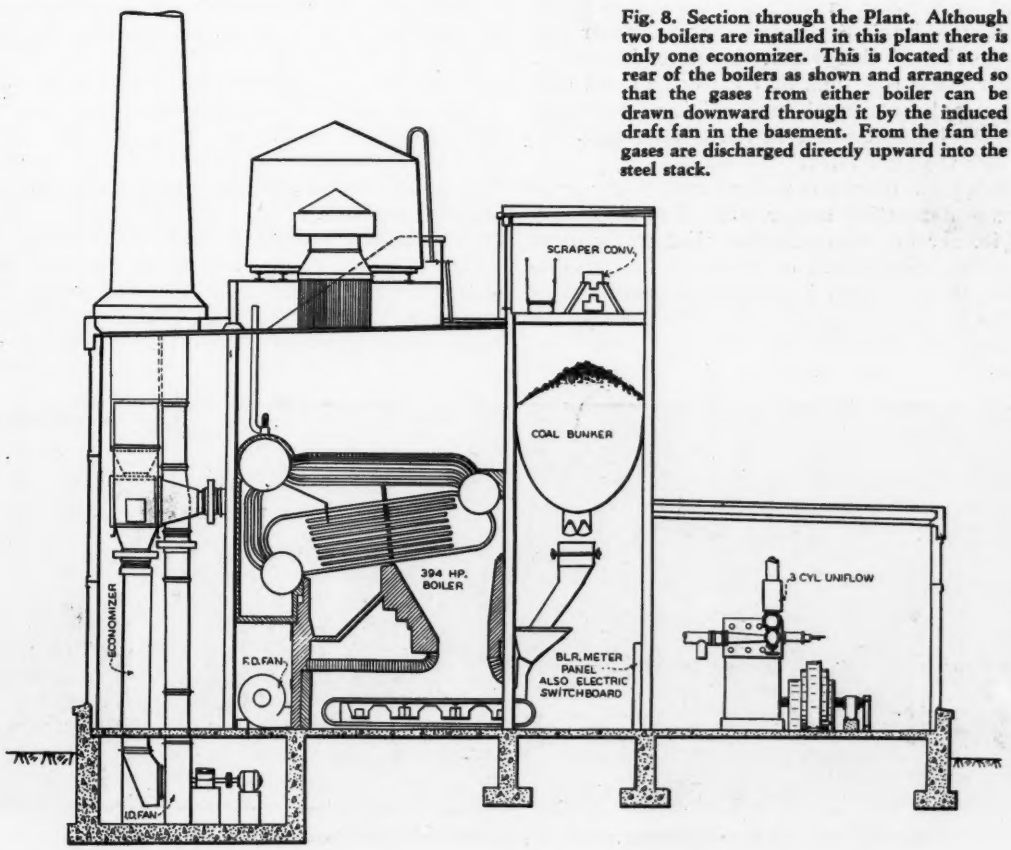


Fig. 8. Section through the Plant. Although two boilers are installed in this plant there is only one economizer. This is located at the rear of the boilers as shown and arranged so that the gases from either boiler can be drawn downward through it by the induced draft fan in the basement. From the fan the gases are discharged directly upward into the steel stack.

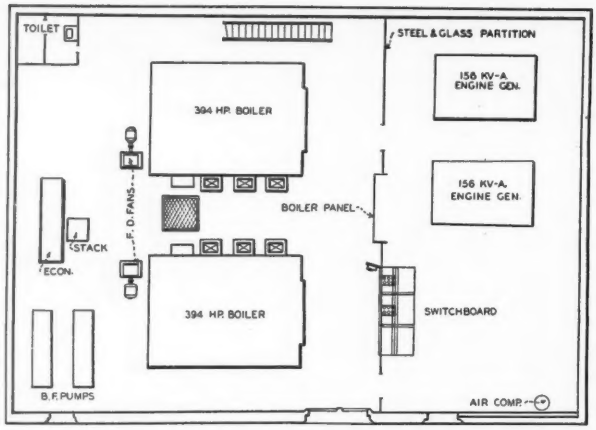


Fig. 10. Plan, showing arrangement of equipment

meter measuring process steam flow, feed water temperature and pressure; and finally, a liquid level gage. This panel is entirely of Bailey Meter Co. make except the liquid level gage which is a Foxboro instrument.

Feed Water from Still House

A good general idea of the station can be obtained from the flow diagram in Fig. 5 which shows the principal steam and water piping as well as the equipment. As shown by this diagram, the water supply system is associated with the processes in the still house. A 25,000 gal. roof tank on the still house provides water used in the cooling and condensing processes in the alcohol plant. This water is raised to a temperature of approximately 160 deg. in the processes and as a consequence it is desirable to use this for feed water purposes. A portion of this water, therefore, is pumped to the boiler house roof tank by means of a small electrically operated centrifugal pump. This pump is controlled by the head of water in the storage tank and always keeps the tank filled.

From this tank, the warm water flows by gravity to the Cochrane deaerating heater which has a capacity of 40,000 lb. per hr. when supplied with water at 60 deg. Since the temperature of the water is considerably higher than 60 deg., it can handle considerably more water in this particular plant than the 40,000 lb. rated capacity.

Two boiler feed pumps are installed, either one of which can carry the normal plant load. These pumps, which are Worthington duplex, outside packed steam pumps, take suction from the deaerating heater and deliver it through a Venturi meter into the economizer, and from the latter into the boilers.

Feed water is treated by a system developed by the Hall Laboratories. Two chemical tanks are provided, one containing caustic and the other phosphate. The caustic is fed continuously and is introduced into the system at the suction side of the boiler feed pump through an eductor which governs the flow in accordance with the requirements as indicated by periodic chemical analysis of the boiler water. The phosphate on the other hand is introduced just before the water enters the boiler proper and this is fed intermittently and automatically by means of a special pump and a solenoid operated valve controlled by a Telechron operated timing device. The pump is special only in that it is trimmed entirely with stainless steel.

The caustic solution is a mixture of caustic and Santosite. The purpose of the Santosite is to chemically fix any traces of oxygen which might get through the deaerating heater. The caustic is necessary to maintain the proper alkalinity in the boiler water and to increase the pH value of the water passing through the economizer.

By feeding the phosphate just before the water enters the boiler, the possibility of pre-boiler deposition is avoided. If the phosphate was introduced ahead of the economizer as is the case with the caustic, the phosphate could cause eventual deposition in the economizer.

As will be noted a number of sampling water coolers are provided, these being permanently connected to various parts of the water system. The feed water chemist draws water from these sampling tanks periodically for analysis and the subsequent treatment is based upon the results of these analyses.

The feed water level in the boilers is controlled by Bailey feed water regulators and the feed pump with Fisher governors.

The boilers operate normally at a steam pressure of 260 lb. gage. The feed water temperature out of the heater is usually around 240 deg. and out of the economizer it averages 300 deg. Main steam from each boiler passes through a non-return valve, a flow meter

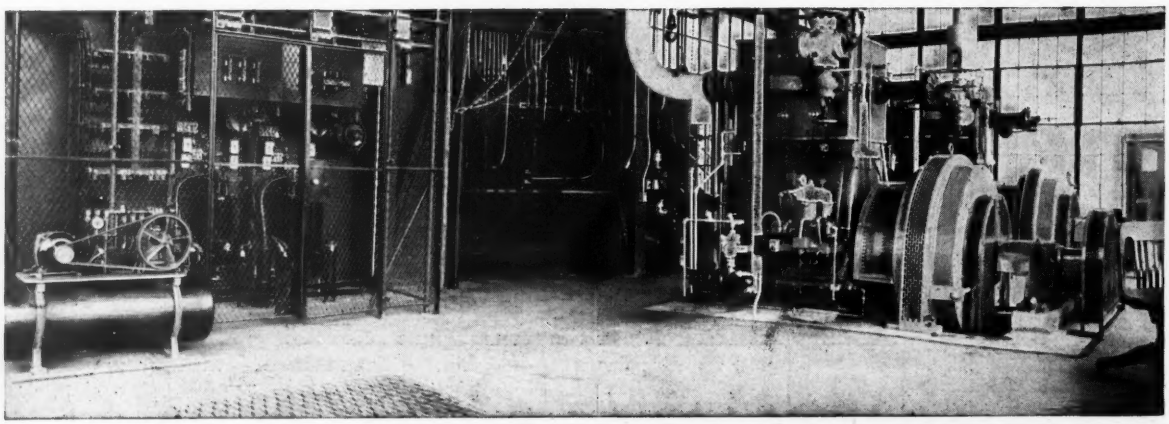


Fig. 11. General view in engine room showing rear of switchboard and boiler meter panel

Principal Equipment at the Power Plant of the U. S. Industrial Alcohol Co., Newark, N. J.

GENERAL

Owners—U. S. Industrial Alcohol Co.

Location—Newark, N. J.

Consulting Engineers—Thomas E. Murray, Inc., New York.

PRINCIPAL EQUIPMENT

Boilers—Babcock & Wilcox Co.—Two, Class H-4, No. 19 Stirling boilers, 394 hp., designed for 275 lb. gage, 23,000 lb. per hr. max. 3 drums, 323—3¼ in. tubes.

Stokers—Combustion Engineering Co.—Two Coxe chain grate stokers, 7 by 14 ft., driven by 1 hp. General Electric Co. motors through Reeves variable speed transmission.

Economizer—Babcock & Wilcox Co.—One return bend economizer, arranged with ducts and dampers to serve either boiler.

Boiler Brickwork—Rust Engineering Co.

Furnace Arch—M. H. Detrick Co. flat suspended arch.

Soot Blowers—Diamond Power Specialty Corp.—Four Valv-in-head soot blower elements on each boiler.

Safety Valves—Crosby Steam Gage & Valve Co.—Each boiler has two 2½ in. valves.

Boiler Stop Valves—Foster Engineering Co.

Forced Draft Fans—American Blower Corp.—Two fans each driven by constant speed General Electric motor.

Induced Draft Fan—American Blower Corp.—One Sirocco fan driven by constant speed General Electric motor.

Fan Starting Compensators—General Electric with push button control.

Coal Handling Equipment—Jeffrey Mfg. Co.—30 ton per hr. system, consisting of track hopper, apron conveyor, bucket elevator, scraper conveyor and weigh larry, driven by G. E. motors and arranged with interlocks for proper sequence starting and stopping.

Controllers for Coal Handling Equipment—General Electric Co., Trumbull Electric Mfg. Co.

Ash Handling—United Conveyor Corp. Nuveyor ash conveyor with 30 t. tile receiving hopper.

Boiler Feed Pumps—Worthington Pump and Machinery Corp.—Two duplex, outside packed piston pumps 7½ by 4½ by 10 in., 250 lb. steam pressure, 10 lb. back pressure, 325 lb. water pressure.

Feed Water Meter—Builders Iron Foundry—One 3 in., recording, indicating and integrating Venturi meter.

Feed Water Heater—Cochrane Corp.—One 40,000 lb. per hr. cap. deaerating heater, inlet temp. 60 deg. furnished with a 10 in. oil separator, 1½ in. pilot actuated regulating valve. This heater is of the parallel type. The vent condenser is of the U-tube type.

Feed Water Regulators—Bailey Meter Co.

Feed Pump Governors—Fisher Governor Co.

Feed Water Treatment—Hall Laboratories, Inc.

Boiler Meter Panel—Bailey Meter Co.—Panel contains two 7 element multipointer draft gage, for boilers, one 2 element multipointer draft gage for economizer, two Bailey boiler meters, one Bailey fluid meter, one Foxboro liquid level gage.

Combustion Control—Republic Flow Meters Co.—Smoot combustion control arranged with regulators to handle stack or economizer dampers and with one regulator to handle F. D. fan dampers and stoker drives.

Engine Generators—Ames Iron Works—Two 3 cylinder Unaflow engines 8¼ by 9, 250 lb. gage throttle, 10 lb. gage back pressure, direct connected to two Crocker Wheeler Co. alternators. 3 phase, 60 cycle, 450 r.p.m., 240 v., 376 amp. Max. Field current 42 amp., 156 kv-a. continuous at 40 deg. F. with belted Crocker Wheeler exciters, 1800 r.p.m., 115 v., 43.5 amp.

Oil Purifier—Goulds Pumps, Inc.—One Hydroil purifier on each engine.

Air Compressor—Westinghouse Air Brake—One locomotive type, 9½ by 13 by 10, installed to furnish air to combustion control system.

Electric Switchboard—General Electric Co.—Four panels with swinging bracket. Consists of two generator control panels, one regulator panel and one distribution panel. Instruments of the square, non-parallax type. Voltage regulator, G. E., type TA-125-K2, 100-125 v., 25-125 cycles.

High Pressure Steam Valves—Wm. Powell Co.

Small Forged Valves—Edward Valve & Mfg. Co., Inc.

F. W. Treatment Control Valve—Automatic Switch Co.—Controlled by G. E. type TSA automatic time switch with Telechron motor.

High Pressure Steam Trap—Strong, Carlisle & Hammond Co.

Boiler House Roof Tank Pump—Worthington Pump and Machinery Corp.—Centrifugal unit built integral with electric motor by The Master Electric Co.

Fire Pump—Worthington Pump and Machinery Corp.—Blake-Knowles pump.

---

orifice, and a gate valve into the main high pressure steam header. One end of this header supplies the two engines driving the electric generators and the other end runs to the alcohol plant. The steam driven auxiliaries, the feed pumps, the steam jet ash conveyor, and the fire pump also take steam directly from the main steam header.

Each of the two generating units consists of an Ames 3 cylinder Unaflow vertical engine connected to a 125 kw. Crocker Wheeler 240 v., 3 phase, 60 cycle generator with belted exciter. The engines operate at a throttle pressure of 250 lb. gage and exhaust at 10 lb. into a common exhaust steam line to which the exhausts from the steam driven auxiliaries are also connected. This exhaust steam is used in the still house for process purposes.

In addition to the two engines, a small steam driven Westinghouse locomotive type air compressor is also installed in the engine room. This serves the combustion control system.

The electric control board, which as has been explained is located in the boiler room, is of General Electric manufacture of modern design, equipped with square non-parallax type instruments. It consists of two generator control panels, a distribution panel, a voltage regulator panel and a swinging-bracket synchroscope and voltmeter panel. The distribution panel is of the flush mounted type, all switches being of the dead front, toggle type.

Conclusion

Although the plant has not been in operation long enough to permit the presentation of operating data, operation, so far, has been entirely satisfactory both from a thermal standpoint and from a labor standpoint. Two men operate the entire plant with practically no labor involved. One boiler is operated for approximately a month after which it is shut down and the other unit placed on the line. The engines are "changed over" every Monday morning.

In concluding this description we extend our appreciation to the officers of the U. S. Industrial Alcohol Co. for the privilege of inspecting the plant and to Thos. E. Murray, the consulting engineer, for furnishing drawings, photographs and other necessary data.

Pilot Light Lessens Production Losses

Whenever a fuse blew or the overload relay on a starter tripped in a cast-iron foundry and the other motor became inoperative, the workman immediately reported "no power" to the foreman. He would then put in a call for the plant electrician to restore power and with straight-time production in this foundry, a time loss of 15 to 30 minutes while the electrician was being located was resulting in actual production losses and man-hour losses.

To eliminate production losses and to conserve his own time, this plant electrician obtained a small switchboard-type indicating light. This he mounted with a resistor on a slate panel in the foundry, connected it to the 440-volt lines, so that its red glow would be evident from any point in the foundry and indicate to the workmen that power was available and that the shutdown of any one motor did not necessarily indicate a power failure. Since the installation of this indicating light, the workmen have been carefully instructed to operate the reset of the overload relay on the stopped motor, and if this does not restore service, then the electrician is to be called.

The foundry foreman estimates that the installation of this $7 indicating light panel has saved his company at least $600 in labor and production during the four years it has been in service.—Electric Journal.

When Troubles Come With MECHANICAL DRAFT

By J. R. DARNELL
Consulting Engineer
Jenkins Petroleum Process Co.
and Donnelly Process Corp.

Factors Involved in the Movement of Air Are Well Known to Operators but Fan Characteristics Involving Fan Design, Power Required, Capacity, Pressure Differential, Temperatures, Specific Gravity and Many Outside Conditions Give Troubles Galore

MOST FAN TROUBLES, for which plant operators call for help, are not mechanical such as worn or burned out bearings, wheels out of balance or blades eroded, but most generally may be called performance troubles. In most cases investigation has shown that the difficulty may be traced directly to operating conditions and is not inherent in the fan.

All of the reputable fan manufacturers, who sell forced and induced draft fans, have performance tests of each type of fan design and therefore can accurately guarantee performance provided the conditions under which such guarantee was made are actually found in operation.

A fan trouble shooter must know something of electrical engineering, combustion engineering and furnace operation as well as fan engineering. It is easy blandly to lay the blame on a faulty stoker, choked passages in the economizer or air heater, too much excess air, or just incompetent operators, but quite another matter to convince the management by definitely locating the trouble and at the same time keep everyone concerned in good humor. Sometimes the latter condition is hard to meet, no matter how tactful the investigator may be. On the other hand a trouble shooter may be so anxious to keep from "showing up" someone that his investigations will be negative rather than positive. By this I mean that he may show by various test readings that the fan itself is not at fault but if he does not go farther and show positively just where the trouble lies and suggest a reasonable remedy he has failed to conform to the true trouble shooter's traditions of service.

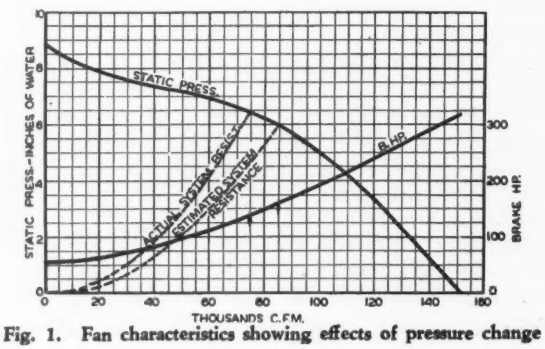


Fig. 1. Fan characteristics showing effects of pressure change

Most of the time, complaints on performance are directed against the induced draft fan and generally it is accused of being the cause of curtailed boiler output. Sometimes, in addition to this complaint, operators will say that the induced draft fan takes more power than guaranteed.

Correct Estimate of Resistance Is Essential

In some cases operators in purchasing the fan have underestimated the resistance under which the fan must operate and then when they fail to get the required boiler capacity, place the blame on the induced draft fan. Once I made a hurried trip to a large eastern chemical plant where the boiler manufacturer who had taken the complete contract for boilers, pulverizers, air heaters and fans was trying to complete acceptance tests but had failed to reach the guaranteed maximum capacity of 300 per cent of rating. All they could get was 260 per cent and the induced draft fan appeared unable to handle as large a volume of flue gas as necessary. Above this load there was a positive pressure in the furnace and the burners would flare back. To the operators this seemed positive proof that the induced draft fan was too small but after I had persuaded them to hook up a wattmeter to the motor they were amazed to find that the motor wasn't taking as much power as its rated capacity. The fan was sold to deliver 85,000 c.f.m. at 6 in. static differential pressure while careful static pressure readings showed that there was slightly more than 6½ in. differential pressure across the fan. The reduced horsepower and the higher pressure revealed to me the cause of the trouble without further investigation, but it was not an easy matter to convince the operators that someone had underestimated the resistance of the system.

Referring to Fig. 1, I showed them that although they had bought a fan which could and would give them 85,000 c.f.m. at 6 in., the resistance through the boiler, air heaters, and duct connections was actually more than had been estimated. When working under this increased resistance, at the same motor speed, I explained to them why they could get only 75,000 c.f.m. through the system.

The boiler, air heater (or economizer), and duct

work of any installation constitute a definite orifice and for a given resistance there is a definite quantity of gas drawn through the system. The resistance for any given volume compared to another volume varies as the square of the volume, or vice versa, to handle twice the volume the pressure must be quadrupled. For example if it requires a static pressure of 6 in. to handle 85,000 c.f.m., then with a fan speed sufficient to give 24 in. pressure the fan will handle 170,000 c.f.m. A line drawn through various points of resistance for different volumes is a parabola and we call this parabolic curve the "system resistance." For a given installation there is one and only one such system resistance and this cannot be changed unless the orifice is changed.

The fan was found to be operating as close to its true test block characteristics as could be determined in the field, but through no fault of the fan manufacturer was not delivering the desired volume. Draft readings taken at various points in the system showed excessive resistance through the air heater. This heater, which was of the plate type, was provided with gas spaces only ½ in. wide and these had become partially clogged with powdered coal ash. Changes in the air heater allowed the fan to operate with less resistance so that the required volume necessary for maximum boiler capacity could be handled without difficulty.

Overloaded Fan Motor

At another time, in a large mid-western motor car plant conditions directly opposite to those in the eastern plant were found. Answering an urgent call for a fan engineer to locate the cause for an overloaded fan motor, even at reduced speed, I found that they were getting the required boiler load but the suction at the fan inlet was very much less than that given in the specifications under which the fan was sold. Here again it was easy to see what was causing the trouble but not so easy to convince the operators that their own engineers were responsible.

The engineering department which prepared the specifications for the purchase of the mechanical draft fans had evidently believed in "playing safe" and had greatly overestimated the resistance required for the induced draft fan. They had asked for a fan to deliver 90,000 c.f.m. at 8.0 in. static pressure. The fan which we sold them required 210 b.hp. and a 225 hp. variable speed motor of the brush shifting type was installed, operating at a full load speed of 500 r.p.m.

At maximum boiler load, corresponding to the volume of 90,000 c.f.m. originally specified, I found that the resistance of the system was only 4 in. and that they were getting this volume and static pressure at a reduced speed of 405 r.p.m. But the overestimated resistance caused just as much trouble as if it had been underestimated, perhaps more so.

A well designed and carefully built fan obeys the theoretical fan laws surprisingly well. For a given system resistance the volume varies directly as the speed, the pressure as the square of the speed and the horsepower as the cube of the speed. But with the same volume at a lower pressure and speed, which necessarily means a different system resistance, the fan must operate nearer to its wide open condition and requires greater horsepower for any given speed than

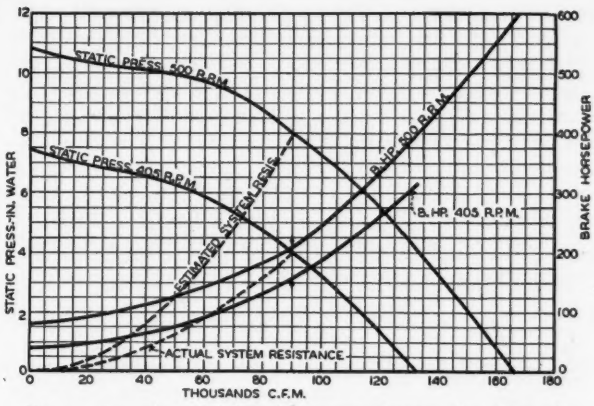


Fig. 2. Fan characteristics with curves showing the effect of incorrect estimates

would exist if it were operated on the same system resistance.

Figure 2 shows the fan and system characteristics for the original conditions as specified and as they actually existed. To deliver 90,000 c.f.m. at 4 in. static pressure the fan required 158 b.hp. at 405 r.p.m. The motor input actually was 188 hp. whereas, in view of the type of motor used, the power characteristics were almost identical with those of the fan, so that at this speed the motor was good for only 120 hp.

Here was a paradoxical situation in which a 225-hp. motor was overloaded when the fan was only taking 158 b.hp.

Air Leakage Overloads Fan

Complaints characterized by overloaded motors are probably the most common but in the great majority of cases the trouble is due to excess volume rather than overestimated pressure. Air leakage into the system accounts for most of the trouble. A typical example may be explained by the conditions I once found in a large central station in the upper Mississippi valley. The complaint concerned the induced draft fan serving two stoker fired boilers. The flue gases from each boiler discharged into a large steel duct at the rear and the induced draft fan connected one end of this duct with a stub stack mounted on the roof. In the basement a forced draft fan supplying air to the underfeed stokers discharged into one end of a duct connecting to the wind boxes of each stoker. The fans were supposed to be large enough to handle a certain maximum capacity of both boilers when operating in battery, or either boiler operating alone. Figure 3 shows a plan view of the boilers, fans and stokers.

At the time I visited this plant they were operating boiler A alone. Boiler B was shut down for cleaning. But in spite of the fact that only one boiler was operating, when they attempted to get 200 per cent rating which was much less load than when the boilers were operating together, the fan motor was overloaded and the operators were greatly disturbed. The fan only cost about $500 but the management of the power company were holding back about $40,000 from the contractor who had purchased and installed all of the equipment. Immediate determination of the cause of the overloaded motor was therefore highly important.

One of the first things that a trouble shooter must check when investigating performance troubles for in-

duced draft fans is the temperature at which the fan is working. An induced draft fan is always sold to deliver a certain volume at a specified pressure, corresponding to a given speed and at a *certain temperature*. In this case the fan was supposed to operate at 630 deg. for maximum conditions but actual measurement showed only 300 deg. This immediately indicated that there might be air infiltration into the system. Analysis of flue gas leaving the boiler gave 13 to 14 per cent CO_2 but samples taken at the fan inlet indicated 4 to 5 per cent CO_2. The evidence then was conclusive that there was a tremendous leakage of air into the fan. It was found that this leakage was coming from boiler B although the uptake damper was supposedly closed. Draft readings taken back of this damper showed about —1.0 in. and there was approximately —0.3 in. draft in the fire box above the stoker. Crawling into the fire box, I could feel a strong blast of air coming through the stoker tuyeres. Further investigation showed that the air from the forced draft fan which was supplying the air for combustion at boiler A was passing through a duct underneath the wind box of boiler B and part of this air was leaking through the dampers thence into the setting of boiler B. Tightly calking these dampers stopped the air leakage and allowed boiler A to operate at considerably increased capacity with no overloading of the induced draft motor. The fan was exonerated and the $40,000 released for payment.

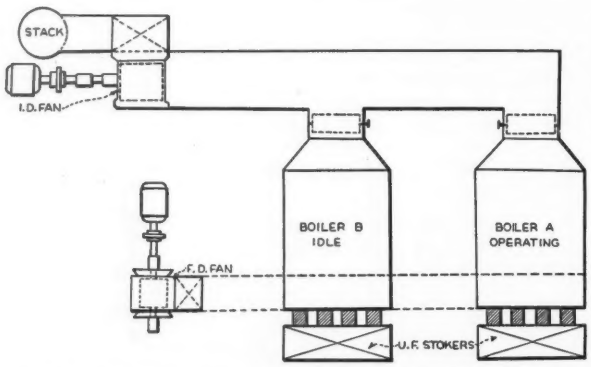


Fig. 3. Layout of system in which air leaks give trouble

This case, along with many others, demonstrated the advisability of having by-pass dampers of the sliding type which will effectively prevent leakage where boilers are connected to a common draft system and one is cut off from the others. Sliding dampers should be provided at both the forced and induced ends of the system.

Few Complaints Against Forced Draft Fans

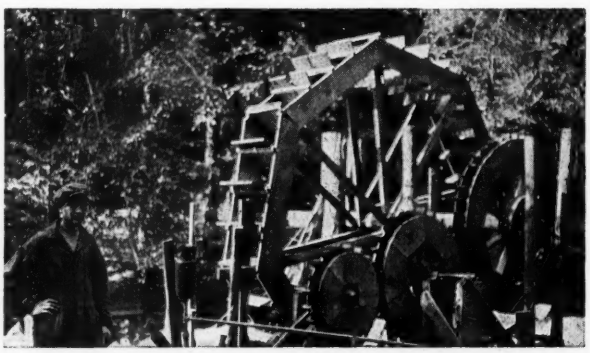
Forced draft fans occasionally are blamed for performance troubles but most designs have wheels with backwardly curved blades which provide the fans with non-overloading horsepower characteristics. In view of this, the percentage of performance complaints against forced draft as compared to induced draft fans is small. Unfortunately fans having wheels with non-overloading characteristics have seldom been used successfully for induced draft. In the first place there is a strong tendency for soot and ash dust, often found in flue gas, to collect unevenly on the under side of the blades. This will soon throw the wheel out of balance, damage the bearings and throw an extra load in the motor. Secondly, wheels of this type have steeper pressure characteristics than fans generally used for induced draft.

In general, forced draft fans require large changes in pressure for small changes in volume whereas the ideal induced draft fan would be one with little or no change in pressure over a wide range of volumes.

But purchasers of forced draft fans have not always selected non-overloading fans and in some cases have had performance troubles for which they blamed the fan. Also in a few peculiar cases I have found non-overloading fans which were overloaded. These will be discussed later.

The Spirit of Mr. Goldberg

Gold miner D. Heiser has constructed a unique water wheel for operating an "Arrastra" which is used for crushing up gold bearing ore. Water is diverted from the river and directed against the paddles of the water wheel which is of the undershot type.



This water wheel operates a series of three wooden cog wheels, which in turn drives a vertical shaft to which is secured a chain which drags around and around the heavy circular granite boulder, which crushes up the gold bearing ore. The entire plant was built by Mr. Heiser from salvaged wood and is located near West Point, California.

113,000 sq. ft. in a Single Condenser Shell—Correction Note

Diagrams at the top of Fig. 3 of the above article were incorrectly labeled. The three diagrams at the top of page 156 of the March issue from left to right, represent the pressure distribution at the turbine exhaust flange, instead of the velocity distribution as indicated. Correctly interpreted, each vertical row represents the pressure distribution at the flange, the velocity distribution at the flange and the velocity distribution through the tubes, for three different arrangements: Original spacing, tubes staggered 30 deg. at the top, 20 deg. at the bottom, and tubes staggered 45 deg. at the top and 20 deg. at the bottom.

Measuring High Steam Temperatures

Thermocouples are easily constructed and Offer Satisfactory Accuracy for Temperatures up to 1000 Deg. F.

By Gustaf A. Gaffert*

WHEN OBTAINING DATA to enable the engineer to make computations regarding the thermal performance of steam and vapor driven machinery, it is necessary to make several measurements. One of the most fundamental is that of obtaining average temperature readings of certain phases, and it may be somewhat startling to some engineers to know that nothing is more difficult than to obtain precise measurements, especially with elevated temperatures approaching 800 to 900 deg. F. Sometimes the physical limitations of heat carrying equipment dictates the use of a particular method with its inherent inaccuracy and limitations.

If we confine ourselves to the range most commonly encountered in the modern power plant, namely 0-900 deg. F., we find that two methods of measurement stand out prominently: one, the use of the mercury filled glass stem thermometer; second, the use of the thermocouple pyrometer. Practically all mercury thermometers used in the power plant are constructed for full immersion. By full immersion we mean that the whole thermometer must be immersed in the fluid medium in order that true temperatures may be read directly. It is exceedingly rare, however, to find a full immersion application. This is principally because it is desired that the temperature reading should be plainly visible as an indication of conditions. Where the temperature itself does not exceed 400 deg. F., and one-half of the mercury column of the thermometer is exposed, the error would probably not exceed 2 to 4 deg. F. Also there is the question of time lag when sockets and metal cases are employed for reasons of rugged construction. If the temperature measurement deals with a condition of steady flow, it is entirely correct to assume that, in time, a steady equilibrium condition will be established. There is, however, no assurance that the temperature of the mercury bulb of a thermometer or the thermocouple junction will be exactly at the same temperature as that of the flowing fluid. Some instrument manufacturers are aware of this fact, and research may throw more light on the effect of sockets. Fortunately until recent years temperatures have been limited to 750 deg. F., but we are now experimenting with 800 to 900 deg. F. installations.

*Assistant Professor of Heat-Power Engineering, Worcester Polytechnic, Worcester, Mass.

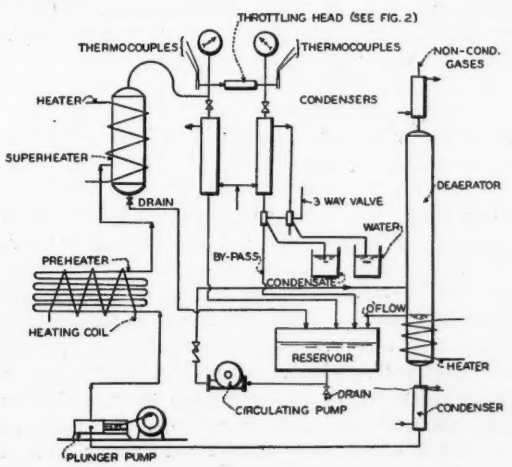


Fig. 1. Diagrammatic layout of experimental apparatus for high temperature research work

When dealing with mercury stem thermometers and high temperatures, we encounter the phenomena of hysteresis. This is the inability of the glass after one exposure to a high temperature to return to its exact original size and a slow growth of elongation of the glass results. Continual heating, or heating and cooling, may in time render a calibration worthless. In short, in attempting to obtain precise measurements we are approaching a point where we must scan critically the accuracy of our measuring devices and conditions of measurement.

Fortunately, in the power plant conditions remain fairly steady at the boiler outlet and turbine steam throttle, for these are inherently set by design conditions. From the author's experience in testing steam turbines for performance data, it was found that when temperatures up to 800 deg. F. are encountered a calibrated glass stem mercury thermometer properly corrected for stem correction will check within 5 to 8 deg. F. with a high grade thermocouple pyrometer. The most important temperature and the most difficult

to measure accurately is that of steam to the turbine throttle. To prevent lag the thermocouple should be exposed directly to the vapor flow and preferably the thermocouple joint should be embedded in a small metal block to prevent continual fluctuations which render exact balancing with a millivoltmeter or potentiometer practically an impossibility.

While engaged on a research problem concerning the properties of a superheated vapor, the author had opportunity to scan the field for temperature measuring devices. One additional condition to those already mentioned was imposed, mainly, that of installing the temperature measuring device in a small space. The test apparatus is shown diagrammatically in Fig. 1. Liquid is drawn from a reservoir by a rotary motor driven pump and discharged to a deaerating column provided with an overflow back to the reservoir. A high pressure plunger pump removes the liquid from the deaerator and forces it through an electrically heated preheater and superheater. The liquid is vaporized and superheated to the desired temperature at a certain superheater pressure and then conducted to a throttling head. Here the vapor pressure and temperature are measured, and, after the vapor has been throttled by means of throttling discs, the pressure and temperature are again measured, giving the necessary throttling data. Finally, the vapor is condensed and weighed.

The problem of measuring the temperatures at the two points mentioned above, involved high temperature (up to 900 deg. F.) with the practical elimination of temperature differential between the fluid and the couple, and installation in a restricted space. If

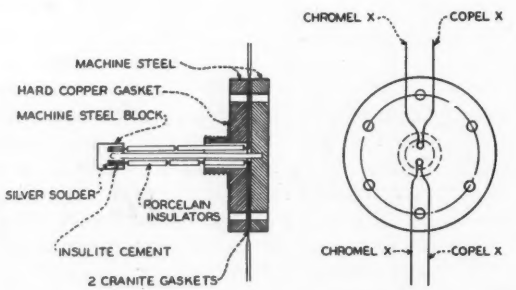


Fig. 2. Details of thermocouple arrangement and high pressure joint

mercury stem thermometers had been used, they would have had considerable stem exposure, would not have been sufficiently rugged and would have been quite costly. Thermocouples of platinum and rhodium were considered but finally couples of chromel-X and copel-X wire of approximately 1/100 in. dia. used with a potentiometer were selected as the most economical.*

To get a satisfactory joint is the first problem in obtaining a good thermocouple. Short sections of the two wires were silver soldered with a gas torch using borax as a flux. Two couples were made for each point of measurement and each embedded half way in a small steel cylinder about 3/8 in. round by 3/8 in. length. The couple was then silver soldered to the steel block and the space around the wires packed with insulite cement. By this construction the thermocouple was directly in the vapor flow path but local fluctuations were dampened.

Considerable experimenting was necessary to develop the necessary soldering technique to make useable thermocouples. The method of soldering is largely that of developing good technique using sufficient flux, i.e., borax, a hot soldering iron and placing the silver solder so as to make a bead of very small thickness joining the two wires. Length of leads

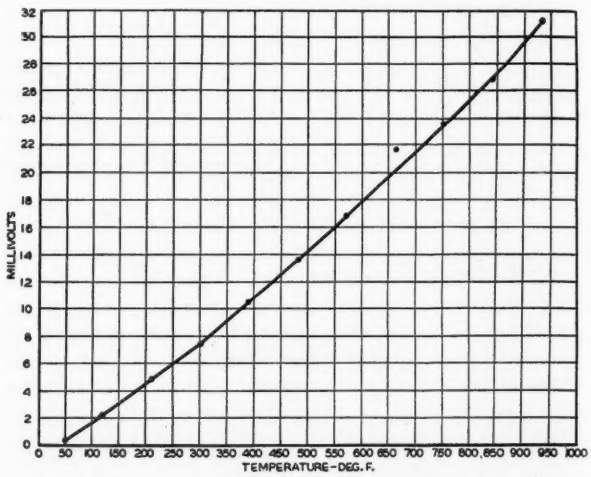


Fig. 3. Approximate calibration curve of chromel-X copel-X thermocouples made from wire approximately 0.01 in. in diameter

should always be such as to place them in an isothermal zone and should be of equal length and preferably of the same material as the thermocouple wires. Joints if not properly made allow parasitic or local electromotive forces and may cause inaccurate millivolt readings. Diameter of wire in this instance was governed largely by manufacturing clearances, but my experience has been that the smaller the diameter the better the couple will respond to temperature fluctuations.

To prevent local short circuit the leads were run through double bore porcelain insulators as far as the flanges forming the joint at the throttling head. These flanges had been constructed quite heavy since pressures up to 500 lb. were to be encoutered under conditions of temperature up to slightly over 900 deg. F. In order to make a tight joint at the throttle head proper, a hard copper gasket was used with a small seat to maintain tightness. To provide a tight joint at the cover only one gasket would have been necessary but to provide insulation for the extension thermocouple leads two thin gaskets of cranite were used and the leads carefully separated and brought out between the bolts as indicated in the detail view of the throttling head, Fig. 2.

As will be noted from Fig. 2, there are two thermocouples at each point of measurement to give a double check on the existing temperatures. Also there is no temperature drop, since by construction both thermocouples are in an isothermal zone and directly in the path of superheated vapor flow. Actually, these were but few difficulties experienced in operation. The cranite gasket leaked but after replacement a few times a tight joint was obtained. Also a short cir-

* EDITOR'S NOTE.—Chromel-alumel, chromel-copel and iron-constantan thermocouples 2 ft. long can be purchased in Nos. 6 to 14 B. and S. ga. at prices ranging from about $2.00 to $3.00 each. Additional lengths running from $0.50 to $1.00 per foot extra.

cuit was caused on one occasion and rendered one couple inoperative for a short period. When equilibrium conditions, i.e., steady pressures and temperatures were obtained the two thermocouples agreed with one another within 5 deg. F. and the average of the two readings was used.

Since a thermocouple is only as good as its calibration considerable time was spent obtaining the temperature-millivolts relation for each couple. The customary reference point was chosen so that it could be duplicated in testing, namely a crushed ice zero reference point inside of a thermos bottle. For temperatures up to 212 deg. F. both the thermocouple and a United States Bureau of Standards calibrated thermometer were immersed in an insulated bath of water which was heated slowly and cooled in the same way. Simultaneous readings of temperatures and millivolts as shown by a potentiometer using a standard cell were obtained.

Another set of readings were taken with each couple inserted in a bath of napthalene which boils in the pure state at 425 deg. F. A third set of readings were taken with the couple in molten lead which melts at 621 deg. F. Finally the couple was placed in a bath of molten flowers of sulphur, melting point 832 deg. F., and several readings taken on the potentiometer. This gave several points for the temperature-millivolt relation, and it was decided to plot the relation so that the chart could be read to one degree. This was probably not entirely justified by the data but it meant less interpolation. Since temperatures were to be used slightly above 900 deg. F. an algebraic equation was derived which allowed extrapolation up to this temperature. Since the millivolt-temperature relation was only slightly curved, this extrapolation was not over a few degrees in error either way. We found that in using sections of wire from the same spool an accuracy of 2 deg. F. could be relied upon up to 425 deg. F. and after establishing one calibration curve several other thermocouples checked the original within 5.5 deg. F. up to 832 deg. F., the boiling point of sulphur. The following are taken from the notes:

For napthalene (boiling point 425 deg. F.) average value of 8 couples 11.577 millivolts.

For sulphur (boiling point 832 deg. F.) average value of 10 couples 26.439 millivolts.

The average deviation in millivolt reading for any one couple of the above did not show more than 3.7 deg. F. maximum deviation. It is, therefore, satisfactory for couples to be made of wire from the same two spools after one calibration curve has been established with high accuracy.

Facilities for calibration are seldom available to the power plant engineer but manufacturers would be glad to furnish a calibration curve at small cost and spools of wire could then be ordered and used with good accuracy. Figure 3 shows about the way the calibration curve will run.

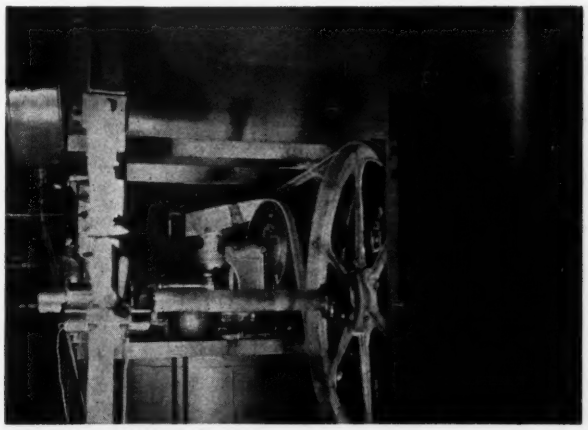
To summarize, it was felt that with the precautions used temperatures could be read accurate to within a total of 5 deg. F. up to the maximum temperature.

It will be appreciated that this accuracy is not essential in all power plant work but will bear out the point that the exact measurement of temperature is a difficult task. In general, ordinary chromel-alumel couples or chromel-X copel-X couples should be accurate to 5 to 10 deg. F. if sufficient precautions are taken in measuring temperatures up to 1000 deg. F. Mercury stem thermometers unless recalibrated repeatedly when used for work between 800 and 900 deg. F. cannot be relied on for precise work because of glass growth and the necessity of correction for stem exposure. When full immersion is possible, conditions are much more favorable for exact work. Consider a steam turbine operating at 0.80 Rankine cycle efficiency ratio with an initial steam pressure of 900 lb. absolute and temperature of 900 deg. F. expanding down to 1 in. Hg. abs. condenser pressure. An error of 5 deg. F. in the initial steam temperature will cause a 3 B.t.u. per lb. error in the heat chargeable to the turbine or a three-fourths of a per cent inherent error in temperature measurement. When it is considered that steam turbine tests and guarantees are within a few per cent of maximum heat rates possible the accurate measurement of temperature becomes an important factor.

Severe Service

BELT DRIVES used on sugar centrifugals offer a perplexing problem for, as shown by the photograph, a 6 in. belt makes a quarter turn between the two pulleys which are set close together. The speed is high, there are heavy overloads and high temperatures are generated by quick stopping and starting.

It is reported by Goodrich that rubber belts with fasteners lasted 30 to 40 days and fasteners have to be replaced at least once a week. Leather belts lasted 10 mo. and had to be shortened every 10 to 14 da. The belts shown were made endless by the Plylock method, however, and two have now been in operation for 5 mo. and three for 3 mo. without need for take-up or repair.



Belt drive on a sugar centrifugal gets hard test

PENSION PAYMENTS to retired employes of the General Electric Company for 1935 totaled $2,589,053, according to the annual report of the Company's pension board. The total number of individuals receiving pensions December 31, 1935, was 3290, one less than for 1934. The average pension age for the year was 67.6, and the average continuous service was 29.5 years. The average amount of the annual pension was $771. Since establishment of the pension plan in 1912 a total of $15,630,719 has been disbursed to retired employes.

COMBUSTION CONTROL

Part XV. Smoot control system of Republic Flow Meters Co., an air operated master controlled system using either air or oil operated regulators

COMPLEXITIES of modern industrial processes make automatic control a necessity and the scope of this type of equipment has broadened rapidly of recent years. Combustion control, although but one phase of a more general problem, is by no means the simplest, involving as it does, the feeding of fuel and air in a definite ratio in proportion to the steam load.

Smoot control, incorporating what the Republic Flow Meter Co. consider the four essentials of a good regulator—sensitivity, power, speed and stability, as built for combustion control purposes, consists essentially of a master controller and a group of regulators all acting in unison, each controlling a measured input quantity in a fixed ratio to the others, so as to maintain *maximum combustion efficiency* while holding constant steam pressure.

Means are also provided for changing the air fuel ratio to conform to changes in the quality of fuel and also means of changing from manual to automatic control as desired.

A diagrammatic arrangement of the Smoot system applied to one of a number of unit fired pulverized coal boilers, is shown by Fig. 1. Steam pressure from the header acts on the pressure controller and changes the master air loading pressure in accordance with steam load. The master air loading pressure is in turn applied to the air flow and fuel flow controllers and regulates the heat input to the boiler.

Nomenclature in the control field is far from standardized and various manufacturers have different names. The differences in some cases are easily detected while in others confusion may result unless the details are known. One of these cases is in connection with the Smoot designation of panels.

For instance, the panel shown by Fig. 2 if used for a single boiler is termed a master panel and not a boiler panel. If arranged as shown by the headpiece, with several boilers controlled from the same panel, it is also a master panel. If the panel shown by Fig. 2 is used simply as a control unit for a number of boilers each with an individual panel as in Fig. 1, the control panel is termed a supermaster.

For instance, the panel shown by Fig. 2, if used for a single boiler (or group of boilers acting as a unit as with line shaft stoker drive) is termed a single unit master controller. The manometers at the top indicate the fuel controller and air controller loading pressure. If the panel is extended as shown in the view above, with a transfer valve to allow complete individual control of each boiler, it is termed a sectional master controller panel. The fuel controller and air controller loading pressure for each boiler is indicated on the manometers above. If on the other hand a panel such as Fig. 2 is used simply as a central control point for a number of boilers by means of master air loading pressure it is termed a supermaster panel. The relative air loading to each boiler is then indicated by the manometer at the top. When a supermaster controller is used each boiler is provided with a panel similar to the first but with the steam pressure regulator replaced by the master air loading line from the supermaster panel. This individual panel is termed a boiler master panel and may or may not be provided with provision for manual control.

Referring specifically to the supermaster arrangement shown by Fig. 1, the arrangement and details of the panel are shown by Fig. 2. Under manual control

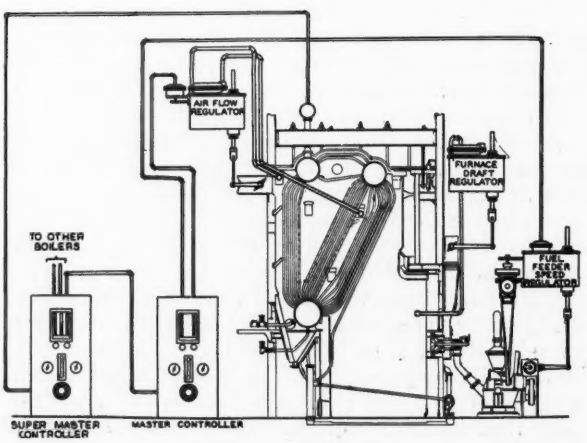


Fig. 1. Diagrammatic arrangement of Smoot Control applied to a unit pulverizer installation

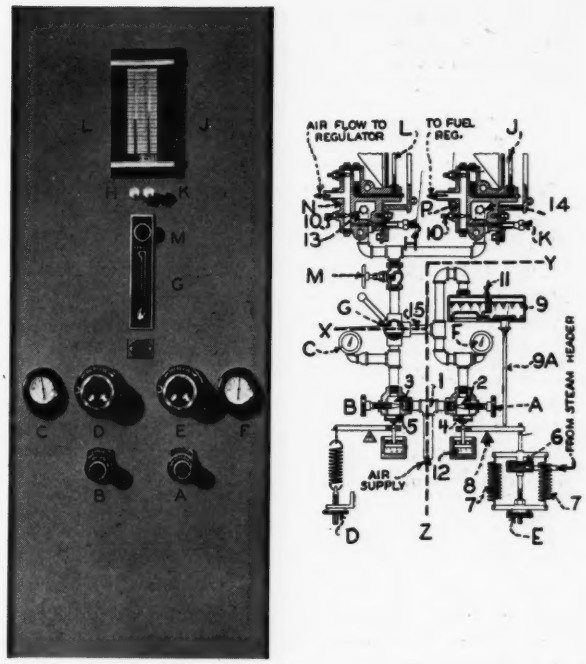


Fig. 2. Arrangement of the Master panel and steam pressure regulator

For explanatory purposes the diagrammatic arrangement of equipment at the right may be divided into three parts: First, the regulator loading elements above the dotted line X-Y; second, the steam pressure control element to the right of line Y-Z; third, the manual control element to the left of line X-Z. Either of the latter may be connected to the first by means of the three way cock or transfer valve G. With G in the position shown, the regular loading elements are under automatic control. When G is in the other position the elements or boilers are under manual control.

Air pressure at from 5 to 100 lb. is piped to the tee 1 and throttled through needle valves A and B to chambers 2 and 3 where, for any given setting of A and B, the pressure is controlled by the opening of cup valves 4 and 5. The maximum loading pressure is about 10 in. of mercury. For manual operation cup valve 5 is opened or closed from the front of the board by handwheel D. For automatic control, valve 4 is connected by a weighbeam with the spring loaded diaphragm 6 responsive to changes in header steam pressure.

In addition to the moments exerted by diaphragm 6 and spring 7 around the weighbeam fulcrum 8, there are two moments proportional to the air loading pressure, i.e., a counterclockwise moment from the cup valve 4 and a clockwise moment acting through rod 9A from compensator 9. The compensator, partially filled with glycerine, is divided into two parts separated by a partition with an adjustable orifice so that the position of screw 11 determines the time lag for pressure equalization between the two chambers after a change of air loading pressure. Under the action of the compensator the master regulator operates to control the fuel and air so as to maintain a substantially constant steam pressure.

Cup valve 4 is in the closed position as shown for maximum air loading pressure (which corresponds to maximum steam load). A drop in steam load will cause an increase in steam pressure which is immediately effective in opening cup valve 4 and reducing the loading pressure or rate of firing. As the rate of firing is reduced the pressure tends to drop more and tip the weighbeam clockwise. Simultaneously the pressure above the compensator diaphragm drops tending to tip the weighbeam counterclockwise. If the two rates of pressure change agree, the cup valve position remains unchanged; if they do not, there is a further readjustment of position until the necessary balance is reached.

The air loading pressure is effective through transfer valve G and valve M on the regulator loading elements N and P. The panel as shown is a master panel for a single boiler, element N being connected to the air flow regulator and element P to the fuel regulator. The ratio of the loading pressures between these two elements, that is, the air-fuel ratio, may be adjusted from the front of the panel by leakoff valves H and K, the respective loading pressures being indicated by manometers J and L. Additional loading elements may be added as required.

On the front view of the panel (which might be an individual master panel for one boiler or a supermaster panel for a battery of boilers), handwheel E controls the loading of spring 7, i.e., the normal steam pressure; handwheels A and B control the air supply to the manual and pressure cup valves and handwheel D the air loading for manual control. The two gages C and F shown indicate the master loading pressure in each system. They should be brought to the same value before changing from one type of control to the other.

the loading pressure for the entire system is controlled by handwheel D.

Under automatic control the loading air pressure is regulated by variations in header pressure acting under a spring loaded diaphragm to move a leakoff valve. Under the action of the compensator the steam pressure regulator acts to maintain constant header pressure at all loads. This normal steam pressure may be changed from the front of the panel by handwheel E. Loading pressures on each side are indicated by gages C and F and when changing from one method of control to another these pressures should be brought together or equalized before the changeover which is accomplished by a three way cock or transfer valve.

A loading element as shown at the top of Fig. 2 is provided for each boiler. All elements may be adjusted as a unit from valve M or individual boilers may be adjusted by controlling the leakoff from valves H and K. On the boiler panel the steam pressure controller is eliminated, the master loading pressures from the supermaster loading elements being piped to the transfer valve on the individual boiler panels.

On these panels the valve M becomes a rating ratio valve by which the proportion of the total load carried by the boiler may be varied. This same adjustment may be made from the supermaster panel by valves H and K. One regulator loading element is provided for the fuel and one for the air and the manometers, which on the supermaster, indicated relative loadings to different boilers, indicate on the master panel the ratio of air to fuel. This ratio, which may be read by means of an adjustable slider or ratio indicator, may be adjusted by means of valves H or K. More than two loading elements may be used with the panel if desired.

From the regulator loading elements the air loading pressure is carried to the regulators which control the dampers and fuel feed. These regulators as shown in detail by Figs. 3 and 4, may be of either the air or oil operated type, the former being more popular for industrial boiler plant service as but one air pipe is required and an air supply is already available. For outdoor service air is not desirable due to the danger of condensation and freezing.

At the air flow regulator the air loading pressure is balanced against the draft loss through the boiler by an arrangement such as shown by Fig. 5. Unbalance between the loading pressure and draft loss tips the weighbeam or the regulator and operates the damper to bring about a balance. Inasmuch as the draft loss varies as the square of the gas flow (proportional to the air supply) through the boiler and balances the loading pressure, the air supply varies as the square root of the air loading pressure.

In the fuel feed regulator the air loading pressure is balanced by the downward pull of a governor element as shown by Fig. 6. The fuel feed is proportional to the feeder speed. The governor casing, filled with oil, is driven from the feeder shaft and in rotating develops a pressure, which acts downward on a pressure disk causing a downward pull, varying as the square of the speed to balance the air loading pressure. The regulator moves to correct any unbalance by changing the feeder speed through a rheostat. The speed of the governor and consequently the fuel feed is thus proportional to the square root of the air loading pressure, or, directly proportional to the air supply thus

Fig. 3. The Smoot Series "60" air operated regulator

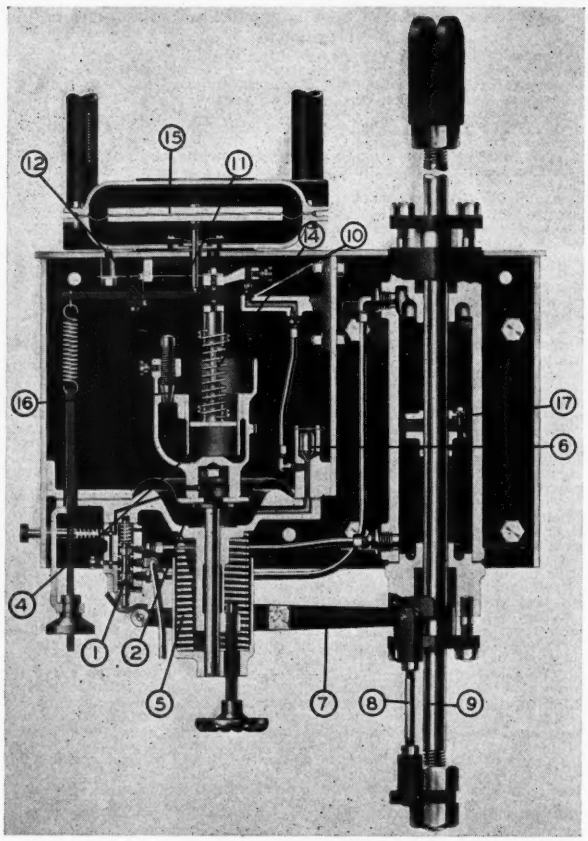
Compressed air at from 30 to 100 lb. pressure is piped to the middle section of pilot valve 1 and throttled through the bleed valves as shown to a pressure of about 1 lb. in the amplifier diaphragm chamber 2. This diaphragm carries the dashpot 4 and its upward movement is opposed by compression spring 5 and is protected from excess pressure by relief valve 6. One end of return motion lever 7, which is pivoted on spring cup retainer 5, acts on pilot valve 1 while the other end is connected through rod 8 to piston rod 9.

Air flow from the diaphragm chamber is through multiplying valve 10 which is covered, or partially covered, by the end of weighbeam 11. This weighbeam is pivoted around 12 and connected with the dashpot by means of Picard spring 14.

For stable operating conditions pilot valve 1 is held in mid position by the balanced conditions between the two ends of lever 7. If now the operating diaphragm 15 be moved upward under the action of a change of pressure in the diaphragm chamber, the weighbeam will increase the area of the multiplying valve leakoff and the pressure in chamber 2 will decrease, moving dashpot 4 downward and with it pilot valve 1 to the position shown by the drawing.

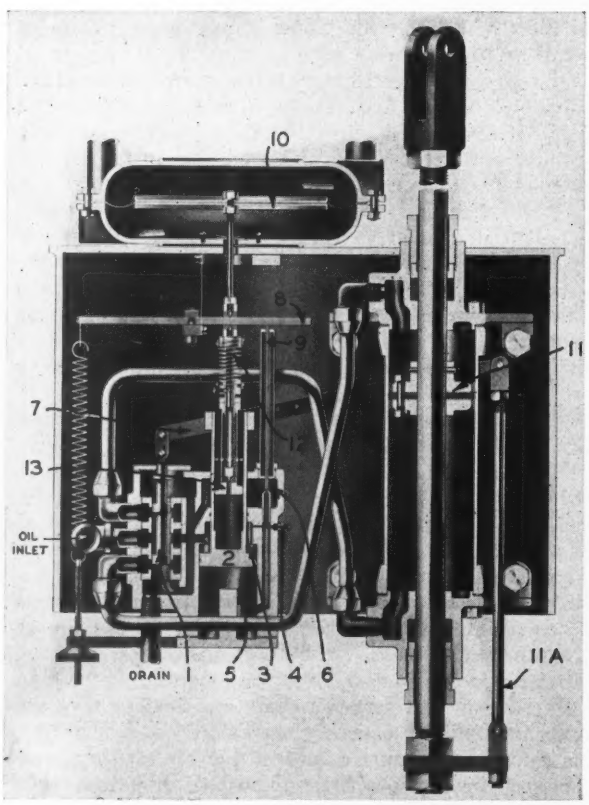
This admits operating air to the top of piston and opens the bottom side to atmosphere. The piston is thus forced downward carrying with it the compensating end of lever 7 to return the pilot valve to neutral and lock the piston in a position bearing a definite relation to the position of the weighbeam or diaphragm. An upward movement of the diaphragm is followed by a downward movement of the operating piston 15.

Under the first action of the weighbeam, spring 14 is extended due to the action of oil dashpot 4. It is further extended by the downward movement of the diaphragm. This retarding action, which can be controlled by leak valve 16, lends stability to the action of the regulator.



maintaining the desired air-fuel rates. This ratio may be changed by adjusting the air loading pressure by means of valves H and K of Fig. 2 as explained earlier.

In either the supermaster or sectional master controllers the boilers may be operated in a number of ways. They may all be operated as a unit under either automatic or manual control. The relative ratings between units may be varied. Any one or all boilers may be operated manually and independently of the others. Under any of the above methods of operation, the air-fuel ratio for the individual boilers will be maintained irrespective of the methods of operation, but this ratio may be changed as desired. With the supermaster system any boiler or boilers may be put on base load independently of the others thus giving a degree of flexibility not available with the sectional master controller.



Furnace draft is maintained constant by a single pressure connection to a regulator of the type in Figs. 3 and 4, the single diaphragm being spring loaded as shown.

In some instances definite maximum and minimum limits may be desirable due to characteristics or condition of equipment. Maximum loadings can be set by means of the rating ratio valves on the individual boilers as described previously. Such a method is not applicable to minimum control, however, although this may be accomplished readily by the arrangement shown diagrammatically by Fig. 7. The control of

Fig. 4. The Smoot Series "50" Oil Operated Regulator

Oil under pressure is piped through the oil-inlet to the middle section of pilot valve 1 (shown in the illustration displaced from neutral position). This middle section is connected directly with the upper side of differential piston 2 so that space 3 is filled with oil under full pressure. Through the needle valve 4, oil flows to space 5 at the under side of differential piston 2 and overflows through the multiplying valve 6 to the drain. Pressure in chamber 5 thus varies depending upon the opening of leakoff 6. Lever 7 is pivoted to differential piston 2 and rod 11A.

If, under a change of operating conditions, diaphragm 10 moves downward, weighbeam 8 and valve rod 9 are carried downward to close the leakoff area of the multiplying valve 6. This increases the oil pressure below piston 2 moving it upward and displacing pilot valve 1 upward as shown. This admits oil to the bottom side of operating piston 11, moving it upward and through rod 11A, shifting the pilot valve back to neutral position. Downward movement of diaphragm 10 causes upward movement of piston 11.

As in the air operated regulator, stabilizing action is provided by Picard spring 12 and dashpot 13 which, in this case, is filled with oil up to the level indicated by the dotted line. The action of the dashpot tends to resist movement of the weighbeam and differential piston.

Power cylinders of either type deliver from 360 to 5600 ft. lb. per stroke depending upon the air or oil pressure and dimensions of power cylinder.

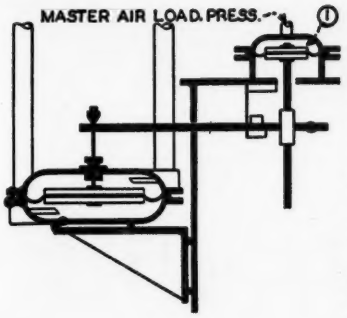


Fig. 5. (Left) Diagrammatic arrangement of the pressure elements of the air flow regulator

Master loading pressure above diaphragm 1 is balanced by the differential pressure or draft loss across the boiler as shown by Fig. 1. A change in master loading pressure upsets this balance and the regulator operates to change the outlet damper until the balance is restored. Inasmuch as the pressure differential varies as the square of the gas flow through the boiler, the air flow will bear the same relation to the master loading pressure (which balances this pressure differential). Expressed the other way, the air flow will vary as the square root of the loading pressure.

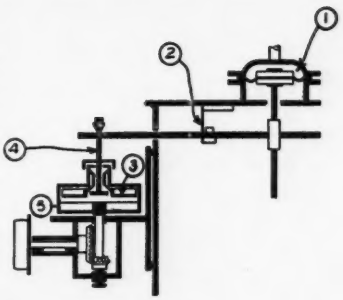


Fig. 6. (Right) The speed governor control as used with Smoot regulator for controlling rate of fuel feed

In this case the master loading pressure at 1 is balanced around the fulcrum 2 by the downward pull of pressure disk 3 through stem 4. (These two parts are not rigidly connected.) This pressure, proportional to the square of the speed, causes a downward pull, is developed by the rotation of casing 5, driven through belt and bevel gears from the pulverizer feeder, on disc 3 which is balanced by the air loading pressure. The rate of fuel feed is therefore proportional to the square root of the loading pressure.

either maximum or minimum is individually adjusted from handwheels on the front of the panel and settings are indicated by pointers. These limit controls have no influences on the operation within the set limit. Such control may be provided on any of the master controllers.

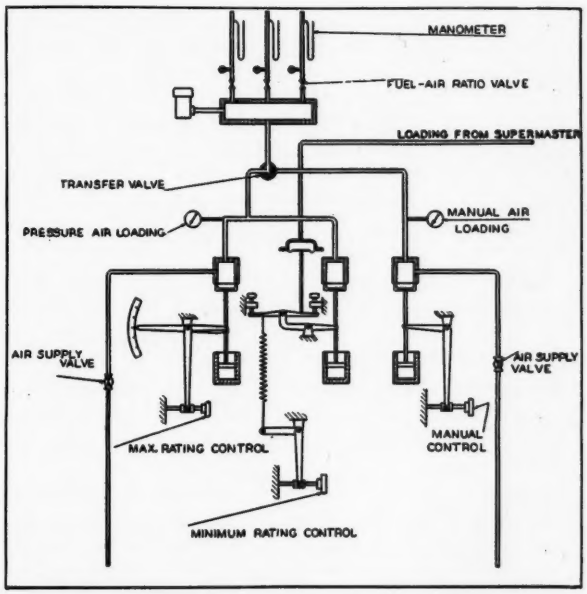


Fig. 7. Schematic arrangement of the maximum and minimum limit control available for application or master controllers if desired

The maximum and minimum rating control is used with pulverized fuel, gas and oil fired boilers to limit the boiler ratings between the desired maximum and minimum limits. It consists of equipment mounted on the master controller panel which sets the upper and lower limits within which the master loading may be changed by the steam pressure variations. It may be seen from the diagram that this master controller is supermaster loaded. The maximum-minimum rating control may be applied to the boiler masters, that is, master loaded from a supermaster to boilers equipped with steam pressure elements.

The master loading of the control consists of a spring loaded cup valve identical in construction with the manual control. The spring is operated by a handwheel on the front of the panel. An indicator is provided which shows the maximum limits. If the master loading pressure from the Supermaster or steam pressure loading exceeds the setting of the maximum rating control, the cup valve relieves.

The minimum rating control is combined with the Supermaster loading cup valve. The cup valve force is produced by either the Supermaster loading pressure or by the tension of the adjustable spring, depending upon which is the greater. The spring tension is adjusted from the front of the panel and an indicator is provided If the master loading pressure produced by the Supermaster loading goes below the setting of the spring tension, the Supermaster loading diaphragm goes against the stop. The cup valve force is then produced by the spring tension only.

With the maximum and minimum rating control, the limits of rating variation may be set at the front of the panel without change in boiler rating.

Boilers are sometimes fired by more than one fuel as blast furnace gas, with which, because of the variation in gas supply, it is necessary to use another fuel, such as oil or coal, to make up the deficiency between the gas supply and the steam demand. In this case there are additional problems; first, controlling the make-up fuel to meet the deficiency in the basic fuel, second, proportioning the total air to the sum of the air requirements of the two fuels.

This necessitates a totalizing master controller, a fuel regulator for each fuel, an air regulator to control the total air and a furnace draft regulator. The fuel regulators measure and control the two fuels and the air regulator measures and controls the total air flow as with boilers fired by a single fuel.

The totalizing master controller loads the fuel and air regulators to change the input of total fuel and total air to control the boiler rating either by manual or steam pressure control. The master controller totalizes the two fuels on an air requirement basis. It maintains the relation between the master loading pressures to the two fuel regulators and to the air regulator, so that the ratio between the total air and the sum of the air requirements of the two fuels is constant at all times. The master controller is also equipped with a fuel ratio divider which controls the division of the total fuel demand between the two fuels to maintain the basic fuel demand within the basic fuel supply.

Novel Exhibit for Foundrymen's Show

A NOVEL TREATMENT in exhibit background construction will be employed by The International Nickel Company, Inc., in their booth at the coming Foundry and Allied Industries Exposition in Detroit. The treatment adopted will make use of a background composed almost entirely of sheets of electrolytic nickel, the basic product used in the production of ferrous and non-ferrous nickel alloys. Electrolytic nickel is the purest form of nickel commercially available. A typical analysis puts the nickel content at 99.95 per cent.

The Annual Convention of the American Foundrymen's Association will also be held in conjunction with the Exposition at Convention Hall, Detroit, from May 5th to 9th.

Seals *against* Fluid Pressure

The problem of preventing leaks in the power plant is complicated in the extreme, involving machine design, selection of metals and other materials, lubrication problems and skilled workmanship. This article outlines an approach to the solutions from the viewpoint of the power plant engineer and will be followed in future issues by articles dealing with specific phases of the problem.

THROUGHOUT the power plant and the industry which it serves, nearly every piece of equipment or machine employs, somewhere in its construction, some means to prevent the escape of a fluid through a passage made necessary for construction or operating reasons. This problem of making seals is as old as civilization. No sooner were liquid containers conceived than the question of stopping the leaks was encountered and throughout industrial history the problem has remained and is today probably more alive than ever before.

What a romantic story could be told about the search for materials that would seal necessary joints in pipes and vessels containing liquids and gases used in our daily living! There were journeys into tropical jungles and swamps for vegetable fibers; trading ships sailed the high seas to exchange trinkets of civilization for rubber gathered by native slaves; the great cow countries have yielded hides to stop the leaks of industry; mines are rendering their service in furnishing copper, lead, asbestos, iron, nickel; scientific laboratories have been invaded and forced to yield such products as aluminum, monel metal, graphite, plastics, cements; likewise the designer has stepped into the picture to change the form of joints and to build materials into leakless seals; the artisan has done his part by working to micrometer measurements in forming surfaces and pipe threads, also in welding and soldering joints; factories have produced an array of tools, machines and devices for making joints, screwed, welded and riveted; so exacting are requirements that the x-ray has become an essential, in fact the problem of making seals against fluid pressure involves direct and indirect application of the sciences of chemistry, physics, zoology, botany, and mathematics in many of their branches.

Packing Specialists Developed

As the seriousness of packing troubles made themselves manifest, the necessity developed specialists who have entered the field of manufacture, and with this step was inaugurated an industry that is world wide in extent, vast in resources and numbers of employes engaged in the gathering of raw materials, manufacturing and selling the products over the counters of stores in even the most out-of-the-way places. So diversified have been the solutions of packing and gasket problems offered by manufacturers specialized in this field that general standards have not been accepted by the trade although there is a growing knowledge of the characteristics of materials used for packing and points for packing are being designed with greater care.

Engineers are prone to think of packing and gaskets as expedients resorted to as a result of poor workmanship in forming joint surfaces. While in some cases this may be the truth, the fact remains that it has proved more economical to make up joints with packing and gaskets than to rely on skilled workmanship to grind surfaces to a perfect fit, in many cases an almost impossible task.

Recognizing the problem of making seals against fluid pressure as one of major importance, too broad in its scope to be treated adequately in a single article, a series of articles on the subject is being prepared for presentation in Power Plant Engineering during the months to come. This series will deal with the entire problem as related to the operation of power plants, taking up the physical and chemical characteristics of materials used in commercial packing and gaskets; presenting general specifications for packing and gaskets for specific purposes about the power plant including piping, hand and manholes, cylinder heads, rods, shafts and valve stems; giving the standards that have been adopted for pipe threads and precautions necessary in making them; considering also the forming of solid joints by riveting, welding and soldering.

In this article it is only possible to outline the problems of making seals as they confront power plant engineers and to suggest a logical procedure by means of which to secure the most satisfactory joint.

Procedure in Preventing Leaks

First of all the engineer should control, as far as possible, the type and design of joints to be used in his plant. This can definitely be done in the case of

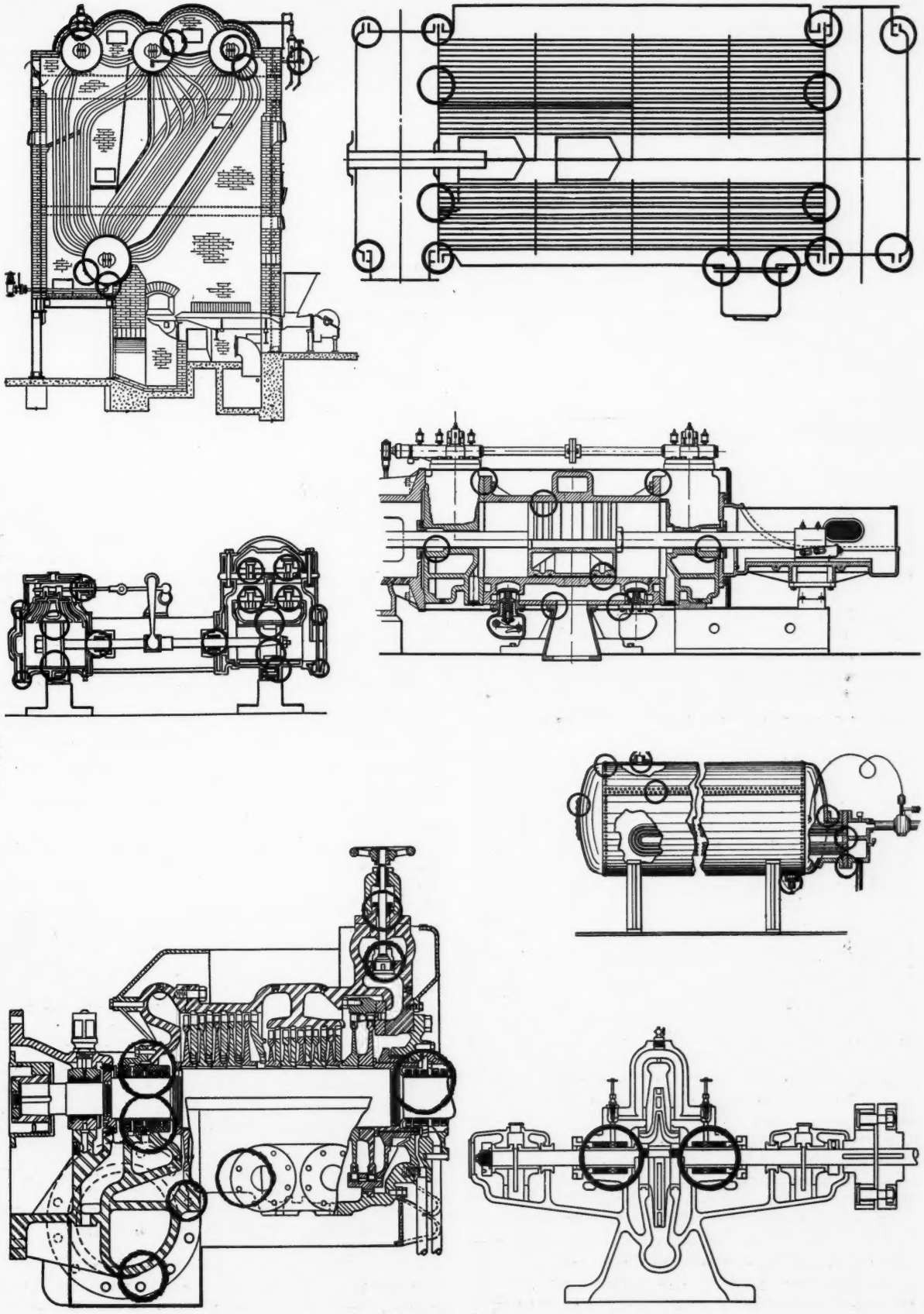


Fig. 1. Sealing methods must be applied at many points in power plant equipment

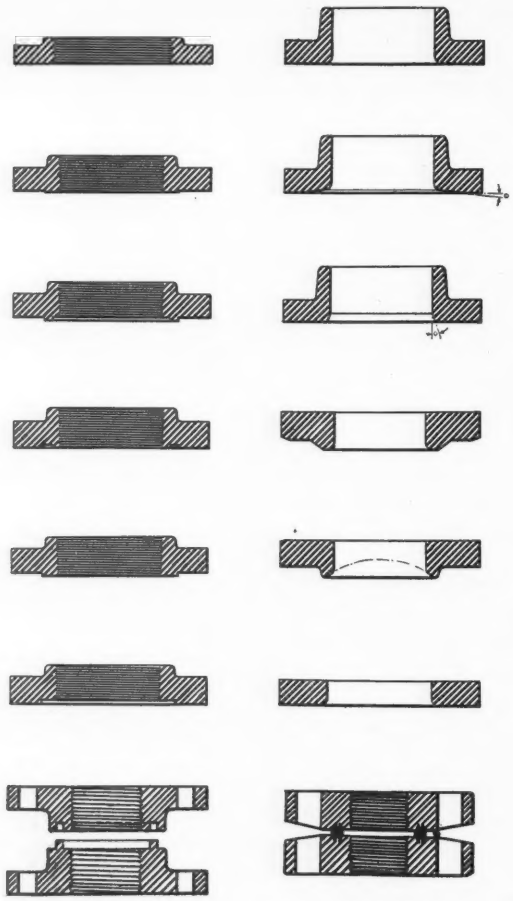


Fig. 2. Flange designs commonly used in fabricating piping

piping and fittings which must be fabricated in the plant and several types of joints are now standard with specifications available from engineering societies. Screw and flange joints have advantages and limitations that are generally known, although many designs of flanges have been worked out for particular purposes and these should be considered in making a selection. Of recent years welding has been making progress and its possibilities in any piping installation should have consideration. For special purposes, soldered fittings may be applied to advantage.

Once the plant is turned over to the engineer for operation, the seemingly endless task of selecting the right kind of gaskets and packing for each particular purpose is immediately encountered for leaks of some kind invariably show up as soon as pressure is applied. It is then that the engineer finds out how successful the designer was in his selection of gasket and packing materials as well as their application. Temperatures, pressures, kinds of fluids contained, metals of which joints are made, frequency of opening joints, structural pressures, lubrication requirements and subjection to wear are extremely important factors to be considered when making a choice of materials and designs to be used in making gaskets and packing.

Extreme care is essential in applying gaskets and packing. Circular and oval gaskets of standard sizes for practically all services are obtainable on the market but they must be carefully installed. Gaskets of irregular shapes in most cases must be cut from sheet packing and this process must be done with extreme care not only to prevent leaks but to prevent waste of packing. Some wear is inevitable with shaft and rod packing but this may be kept at a minimum by proper care in installing and lubricating the packing.

As a rule the highest economy in the use of packing and gaskets is secured by employing the best product

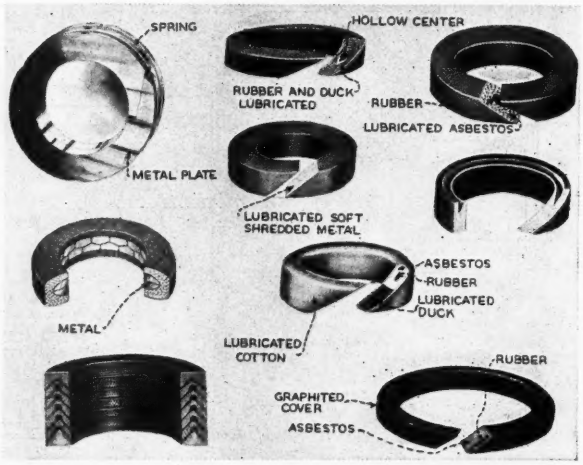


Fig. 3. Rod packings must be resilient, resist wear, offer little friction, resist deterioration of fluid handled, endure existing temperatures and offer no path for passage of fluid

available even though the initial expense may be greater than that of other grades; frequent renewals, the loss of the fluid contained or damage caused by leaks may easily mount far higher in cost than the initial cost of the highest priced product on the market. For this reason a record of the service of packing and gaskets in a power plant will do much to aid the engineer in solving his packing problems.

Future articles in this series will take up all these problems in detail, presenting the reader with information aimed to assist him in preventing leaks about the power plant.

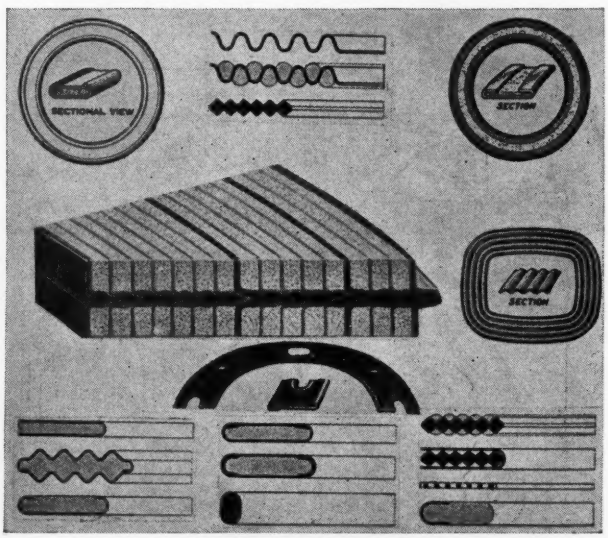


Fig. 4. Various designs of metallic gaskets

Keep Personnel Problems Away from the Courts

By H. S. KNOWLTON

SUCCESSFUL power plant operation is far more than keeping equipment efficiently at work. Selection and handling of personnel are of major importance, no matter how good the design of the station may be. Executive ability, keen judgment of men, fairness of attitude in trying circumstances, knowledge of costs—these things are as vital to first-class administration as technical qualifications. When personnel difficulties get out of control so far as to reach the courts in efforts of staff members to secure reinstatement, something is clearly wrong in plant affairs.

In a specific case which went to the highest court in the state where the episode occurred, a public power plant operating engineer was recessed without pay for several weeks and then dropped from the plant roll. The installation had recently been converted from coal to oil burning. Testimony before a lower court indicated that the consulting engineer who had jurisdiction over the plant during the changeover of firing methods had employed the operating engineer on his supposed record, and had left him in charge of the shift upon being informed that the new man had received special training in handling oil burner equipment.

Conflicting accounts were aired as to the alleged failure of the new engineer to handle the engine reversing gear without "slamming;" inability to start the boilers on time because of lack of knowledge of the oil burners; and finally, the alleged failure of the new employee to see that a blowoff valve was closed following partial unwatering and before the fires were again lighted. On this last count the new man lost his job, his superior ordering the discharge on the ground of grossly unsafe operation.

The lower court sustained the operating engineer's appeal for reinstatement, declaring that insufficient cause for discharge had been shown. The commissioner of the city department concerned appealed to the highest court in the state to grant a writ setting aside the finding, and lost the case. A scanning of testimony filed in the higher court gave rise to the conclusion that something was to be desired on each side of the case in the interest of better operating methods. The operating engineer's qualifications to run an oil burning plant were not very thoroughly canvassed at the time of his employment. They may have been excellent, but should have been ascertained beyond question before such responsibilities were laid upon him.

There was a contention that the valve gearing was improperly adjusted and so was the cause of the slamming, rather than poor handling. This condition, if present, should have given no difficulty in the relationship between the new man and the consultant. It was a question of factual conditions and their remedy where necessary. It was to the interest of both sides that the plant should operate smoothly and efficiently, and altercations over the noise of the engine reversing gear were not the remedy to be applied if something was wrong with the equipment. If the gearing was in proper shape, a little sympathetic instruction as to its proper handling would have put the new engineer on his mettle and brought out the best that was in him.

As to the asserted neglect of caution in leaving the blowoff valve open, the conflicting testimony offered made it difficult to say where the responsibility lay in the specific case; but the circumstances certainly are enlightening. The operating engineer contended that the consultant ordered him to leave the station during the process of preparing the boilers for the next run, going to a remote machine shop to obtain some minor equipment part needed in the plant. He gave sworn testimony that he had ordered the fireman to close the blowoff valve before relighting the burners, and the fireman testified that he had closed the valve as required. The consultant stated that he himself closed the valve and that his action had prevented a disaster.

Out of this evidence it appears that the new engineer failed to make certain that the valve had been shut before leaving the job. He assumed that the fireman would carry out his order, but did not know that it had been done before absenting himself on other duty. The absence of a first-class station log record was a decided handicap in ascertaining just what took place, and even more than this, the inability of the consultant with temporary executive powers and the new engineer to sink their personalities in the good of the plant and do their best to work together, militated against a satisfactory service.

It is hard to escape the conclusion that if the qualifications for successful plant administration outlined above had been present and applied, the case would never have reached the courts, but would have been resolved without legal procedure. The ability to determine the caacity of an operating engineer to run a plant well is of prime importance in every station executive's make-up. If errors of minor character are corrected promptly and not repeated, many a fine engineer may be created out of apparently limited material. On the other hand, if essential qualities are absent and no satisfactory response occurs to friendly and sincere effort to secure improvement, it should be simple to determine the course of action necessary and to carry out the change required in a way that any court would uphold. More than this, if a personnel problem of this kind is justly solvable only by a change, the facts should be so clear to all parties concerned that an appeal to the courts would be beyond consideration.

Reinstatement by legal decree contains many potentialities of future difficulty in the complex business of producing power economically, although it may be necessary in cases of injustice. Judicial balance is therefore one of the most valuable attributes of a successful power plant executive.

Electron Tubes — Principles *and* Applications

The fundamental principles of the triode or three electrode tube. Its use as a relay or as an amplifier.

BY A. W. KRAMER

THE TWO-ELECTRODE TUBE, considered in the preceding article, though useful as a rectifier is quite limited in its functions compared to other types of tubes which we shall now consider. The first, and from a fundamental standpoint the most important of these, is the three electrode tube or triode. This tube differs from the two electrode tube only in that a third element, called the grid, is interposed between the cathode and the plate as shown in Fig. 1. As its name indicates, the grid usually takes the form of a fine wire mesh or screen and is so placed that the electrons in their flight from the cathode to the plate are compelled to pass through the openings in the grid. The openings in the grid are large compared to the size of the wire so it permits of a practically unobstructed flight of the electrons.

The purpose of this grid is to control the passage of these electrons, i.e., the plate current. Like the plate it is furnished with a separate external terminal so that it may be charged electrically. Normally, when no potential is applied to the grid, the tube functions the same as the diode.

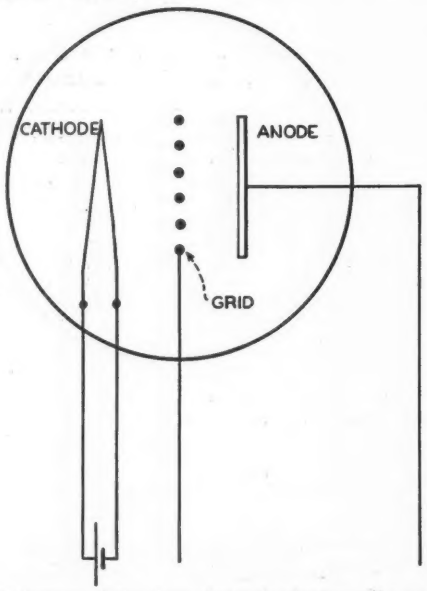


Fig. 1. Diagram of the three electrode electron tube or "triode." The structure is essentially the same as that of the diode, except that a fine wire mesh or grid is mounted between the cathode and the anode. The electrons on their way from the cathode to the anode have to pass through the openings of this grid

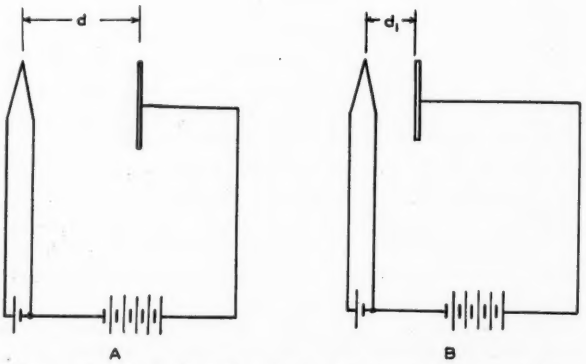


Fig. 2. In the diode, with a fixed plate potential, it is possible to vary the plate current by varying the distance between the cathode and anode. When the distance d is decreased to d_1 the plate current is increased

If, however, by connecting it to a separate battery the grid is made positive or negative with respect to the cathode, the plate current will increase or decrease. When the grid is positive, the plate current increases; when it is negative, the plate current decreases, indeed, it may drop to zero. Furthermore, if the change in plate current and applied grid voltage is carefully measured, it will be found that a very small change in grid voltage produces relatively large changes in plate current. Furthermore, the change in plate current may be made directly proportional to the change in grid voltage. This control action permits the tube to be used as a relay or as an amplifier. The amount of change in grid potential required to effect a certain change in plate current is, of course, much less than would be required to effect a similar change in plate current by direct variation of the plate voltage.

In order to explain this property of the grid in controlling the plate current let us return to the two electrode tube for a moment and consider the effect of varying the distance between the cathode and the plate.

From elementary electrical theory we know that the force between two electric charges varies inversely as the square of the distance between them[1]. In the electron tube, therefore, it would be possible to increase

[1]Coulomb showed experimentally that if two electric charges of magnitude Q_1 and Q_2 are placed a distance r cm. apart in air, they repel each other with a force of $\frac{Q_1 \times Q_2}{r^2}$ dynes.

the plate current by decreasing the distance between the filament and the plate, because if the plate is brought closer to the cathode the positive force acting on the electrons in the space immediately surrounding the cathode is increased. Or, considering it differently, if the cathode and plate are brought closer together, a smaller plate potential is required to maintain the same plate current.

Suppose, however, that instead of moving the plate closer to the cathode, we place a grid in between the filament and the plate and impart a slight positive charge to this grid by connecting it to the positive terminal of the battery "C" as shown in Fig. 3. It is evident that this positively charged grid will act very much like an additional plate and that it will aid the plate in drawing electrons to it. Also, since the grid is much closer to the cathode than the plate, a much smaller positive charge is necessary to exert a given attraction than would be necessary by applying the charge to the plate.

If instead of charging the grid positively, it is given a negative charge, the electrons emitted by the cathode will be repelled by the negative field due to the grid and a smaller proportion of them will reach the plate. If the negative charge on the grid is sufficient the effect of the positive charge on the plate may be completely neutralized, reducing the plate current to zero. In practice, the grid is usually operated at a negative potential in this manner.

The three electrode tube, therefore, in addition to having the rectifying property of the diode, also serves as a relay or, more correctly, as an amplifier. In Fig. 4 the relation between an ordinary magnetic relay and the three electrode tube is shown. When the magnet M is energized by the weak current from the battery B the armature A is attracted downward. This closes the contacts C, permitting current from the local battery L to flow in the bell circuit. In this way a large bell requiring comparatively strong current can be operated from a distant source by a current too weak to operate the bell directly. In the vacuum tube analogy, shown in Fig. 3B, the action is similar. Here the electromagnet with its armature and contacts are replaced by a three electrode tube. The grid corresponds to the magnet. With the grid at zero potential the plate current is insufficient to operate the bell. When the key

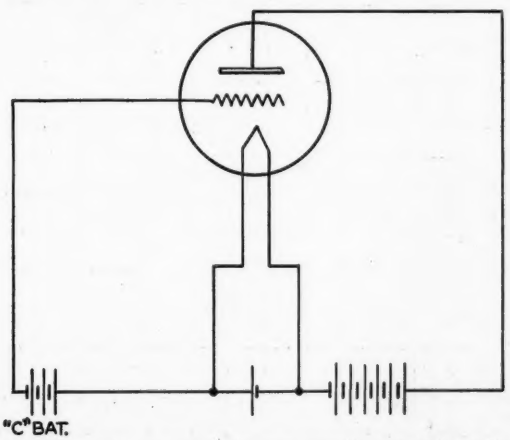


Fig. 3. By means of a small battery, usually called the "C" battery or more properly, the grid bias battery, the grid can be maintained at any required negative potential

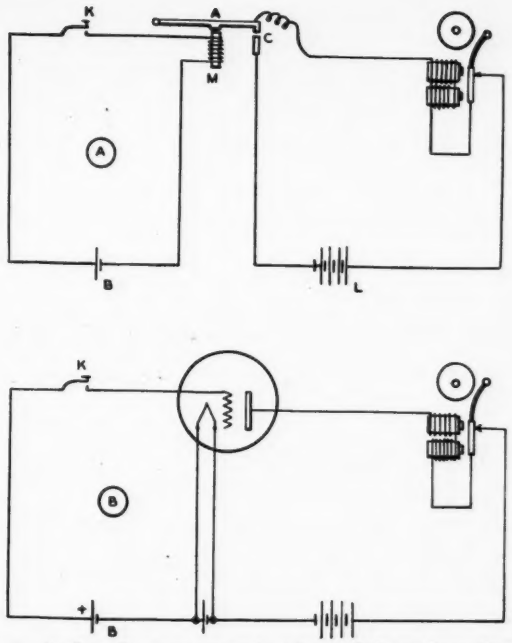


Fig. 4. Analogy between magnetic relay and three electrode tube. In the diagram A, closure of the key K energizes the magnet M causing it to attract the armature A, thus, closing contact C. This allows current from the local battery L to energize the bell. In diagram B, the electron tube takes the place of the magnetic relay. With the grid neutral the plate current is insufficient to energize the bell, but when the grid is given a positive charge by closing the key K, the plate current increases and the bell is energized

is closed, the grid is charged positively causing the plate current to increase and the bell responds.

A more practical way of operating the vacuum tube circuit would be to connect it as shown in Fig. 5. In this case, the key is normally closed and the battery so arranged as to maintain the grid at a negative potential. The negative charge on the grid is such as to neutralize the effect of the plate potential and normally no plate current flows. When the key K is opened, however, the grid potential drops to zero and with its restraining influence on the plate potential removed, the plate current instantly rises to a maximum, operating the bell. It is to be noted that no energy is consumed in maintaining the grid at a negative potential.

This is an exceedingly simple application of the triode and does not begin to do justice to its full capabilities as an amplifier, for in this case no use is made of its ability to vary the plate current in exact accordance with the variation in grid potential. So, let us now consider the circuit in Fig. 6. Here is shown a triode with an ammeter in its plate circuit to indicate the magnitude of the current, and with a battery and potentiometer in the grid circuit so that the grid potential (with respect to the cathode) can be varied between certain positive and negative limits. The voltmeter E_G measures the grid potential. The plate potential, of course, is fixed by the potential of the plate battery.

As the potentiometer slider is moved along the resistance from the negative end to the positive end, the grid potential varies from a negative value to a positive value. This, by virtue of the controlling action of the grid potential upon the plate current causes the latter to vary, and if we plot this variation in plate

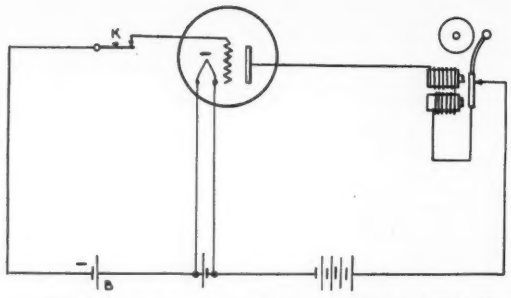


Fig. 5. In this circuit the grid is normally maintained at a sufficiently high value to prevent any plate current from flowing. When the key K is opened the grid charge drops to zero and its restraining influence on the plate current is removed causing plate current to flow

current against the grid potential a curve such as shown in Fig. 7 is obtained. At a grid potential of 30 v. negative no plate current flows. As the grid is made less negative, however, its restraining influence over the electrons emitted by the cathode is diminished and the plate current rises. At —20 volts grid potential, the plate current is about 9 milliamperes. At —10 grid volts, it is 33 milliamperes. And so, for zero grid volts, +10 and +20 the corresponding plate currents are 70, 110 and 150 milliamperes respectively. In other words, a swing in grid potential from —30 to +20 results in a swing in plate current from zero to 150 milliamperes.

So far we have considered only the variation of *current* in the plate circuit. This variation in plate current, however, can also cause a variation in voltage and this is very important. Suppose that in addition to the ammeter in the plate circuit we also connect a resistance R, as shown in Fig. 8. From Ohm's law, we know that when a current is sent through a resistance, a voltage appears across the terminals of this resistance. This is known as the "voltage drop" and its value is given by the well known relation[2]

$$RI = E$$

in which R is the resistance in ohms, I the current in amperes and E the potential in volts.

As a consequence of this relation, the variation in plate current through the resistance R, in Fig. 8, causes a voltage variation across the resistance that is a magnified version of the variation in grid voltage. In other words, the tube acts as a voltage amplifier in this case.

The measure of the amplification of which a tube is capable is known as its amplification factor. This is usually designated by the Greek letter μ (Mu) and is a very important tube characteristic. This factor will be discussed in greater detail later on but for the present it will be sufficient to understand that a tube can be made to function in this manner.

The operation of the electron tube as an amplifier can be represented, graphically, by plotting the plate current wave at right angles to the grid potential wave in the manner shown in Fig. 9. This diagram, it will be noted, makes use of the plate current-grid voltage characteristic. If any point on the lower wave, such as A, is projected up to the curve and then projected at right angles, a point A′ will be obtained on the plate current wave. Thus, each point on the grid potential wave can be translated to a corresponding point on the plate current wave.

In the example shown in Fig. 9 a small alternating potential of 1 volt is applied to the grid and by the method just outlined the corresponding plate current wave is obtained. In this particular example, when the grid is at zero potential, a plate current of 40 milliamperes flows in the plate circuit. When the grid potential becomes 1 volt negative, the plate current drops to 50 milliamperes. Similarly with a grid potential of 1 volt positive, the plate current becomes 50 milliamperes. Thus the application of a 1 volt alternating potential to the grid results in a current in the plate circuit which varies periodically between 30 and 50 milliamperes.

It should be noted that this plate current is not an *alternating* current, but an "undulating" direct current. It varies in its intensity but not in direction; it is a periodically varying *direct* current, equivalent to an alternating current superimposed upon a pure direct current of 40 milliamperes. The wave shape of

[2]Assuming that the circuit has no inductance and unlimited series capacitance, this is merely the expression for dynamic equilibrium in the circuit. Viewed from the standpoint of dynamics the statement asserts that the counter voltage RI must equal the driving electromotive force E. The resistance, R, is the factor which if multiplied by the current establishes the expression for the *resistive* counter voltage. Resistance is the property of an electric circuit which directly opposes the movement of electricity and causes a non-reversible transformation of electrical energy into heat.

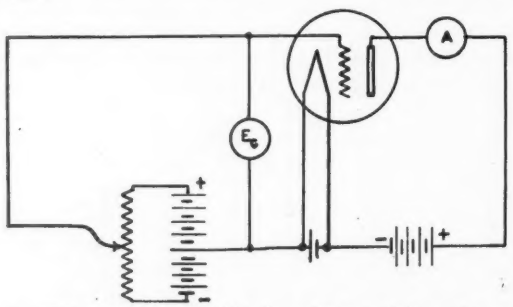


Fig. 6. Triode circuit in which the grid potential can be varied uniformly between certain negative and positive limits by means of the battery and potentiometer in the grid circuit

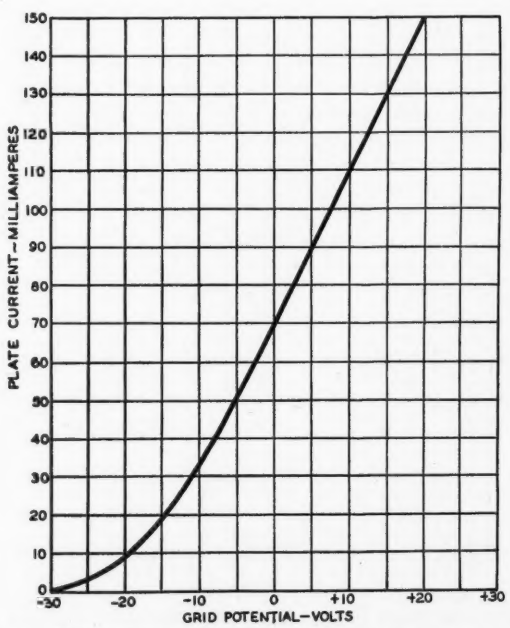


Fig. 7. Plate-current—grid-potential characteristic of a typical medium size triode for a plate voltage of approximately 700 v.

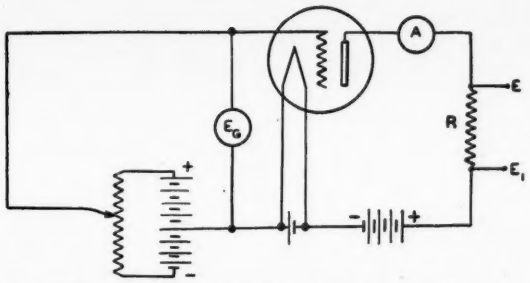


Fig. 8. When a resistance R is introduced into the plate circuit, the varying plate current through this resistance creates a varying voltage across the terminals E E_1 which is an amplified version of the exciting grid potential

this superimposed alternating current is an exact but amplified reproduction of the voltage wave applied to the grid.

From an inspection of this diagram it might be thought a coincidence that the zero grid voltage point falls almost exactly in the center of the straight portion of the slope of the curve, for had it occurred at either the lower or upper bends of the curve, this exact wave shape relation would not have held true. Consider Fig. 10. Here is shown the same curve as in Fig. 9 but in this instance (for the sake of illustration) the zero grid operating point falls on the upper bend of the curve and the linear relationship between grid potential and plate current no longer holds. In this case the plate current is distorted, the lower loop being larger than the upper loop.

It is quite evident then that if the tube is to function properly as an amplifier, the middle portion of the slope of the curve must be used. Now, of course, it must be understood that such a curve as is shown in these diagrams is the characteristic for a definite plate voltage. If a different plate voltage is selected a different curve will result. It might be possible to select a plate voltage such that the zero grid potential fell exactly in the middle of the straight portion of the slope but in practice it is simpler and more expedient to vary the operating point by adjusting the negative potential of the grid by means of a "grid bias battery."

In Fig. 10, for example, to obtain undistorted amplification, it is necessary that the impressed alternating potential operate around a point which is, say, 4 volts negative with respect to the cathode for this line intersects the middle point of the curve as shown. So a small 4-volt battery (or generator) is connected in the grid circuit as shown in Fig. 11 with its negative terminal to the grid. The small alternating current generator, here, is assumed to furnish the exciting potential.

Thus the 1 v.-alternating exciting potential is now superimposed upon the 4 v. negative battery potential and it will oscillate between —3 and —5 v. as shown in Fig. 12.

In this way, by adjusting the "bias" voltage of the grid as it is called, a tube can be made to function as an amplifier or for other purposes as desired. If the operating point is set towards the bottom or top of the curve there will be distortion in the output wave. For some purposes such distortion is desirable and necessary but for undistorted amplification only the straight portion of the characteristic can be used as this provides the linear relationship demanded.

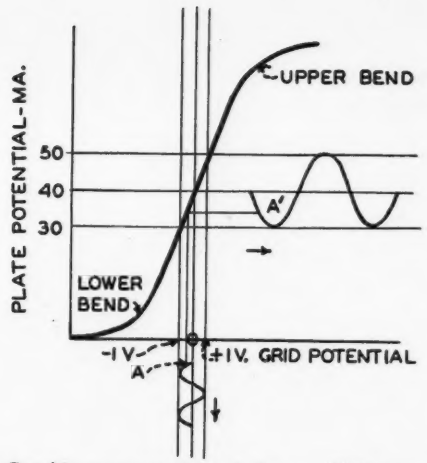


Fig. 9. Graphic representation of the amplifying property of the triode

In considering this amplifying characteristic of the three electrode tube, attention is directed to the slope of the curve. The amount of amplification, it will be noted, is a function of the steepness of the slope of the curve, the steeper the slope the greater the amplification.

In this chapter we have considered only the simplest aspects of the triode's operation but these also are its most fundamental aspects. The diode, it will be recalled, was stated to be, fundamentally, a rectifier. To the extent that the grid can be ignored, the triode also is a rectifier, but when the grid is considered the triode becomes, fundamentally, an amplifier. And, strange as it may seem, these are really the only fundamental properties of all electron tubes—all other characteristics and functions can be derived from these simple properties. If this is clearly understood one should have less trouble in understanding the more involved characteristics and applications to be considered in later articles.

Before we conclude this chapter, a word about the history of the triode. The triode was invented by Dr. Lee De Forest in 1907 as a result of his experiments with the diode which was invented by John A. Fleming. Fleming in 1905 first recognized the rectify-

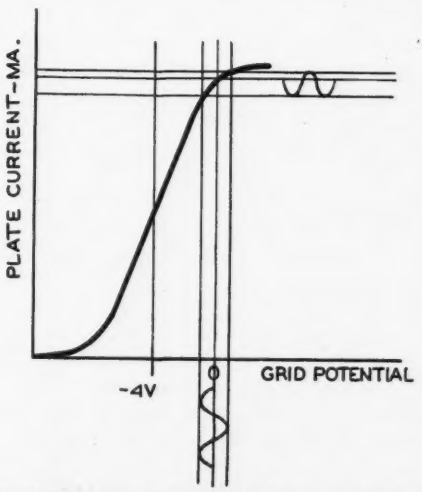


Fig. 10. When the operating point occurs at the bend of the curve distortion results.

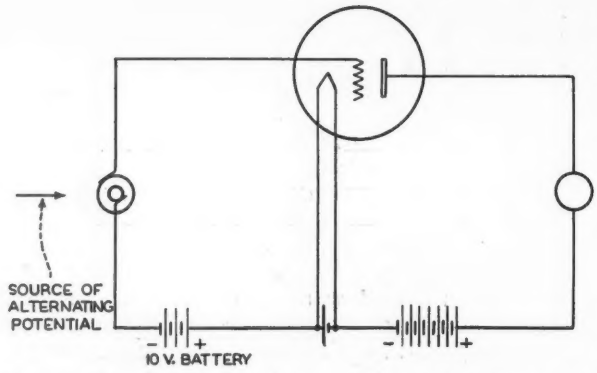


Fig. 11. Diagram showing the use of a grid bias battery in adjusting the operating point of the tube

ing principle of the two electrode tube and obtained a patent on the use of the diode as a detector of high frequency electrical oscillations. This patent[3] became one of the fundamental patents in electron tube development.

Fleming worked in England. In America, Lee De Forest also was engaged in the development of a system of wireless telegraphy and made use of the Fleming valve as it was then known. It was the best detector of wireless signals that had been developed up to that time but its functions. naturally were limited to those of a rectifier. It was during these experiments that De Forest conceived the idea of introducing a third element into the tube. A simple thing, and yet perhaps the most important single invention ever made for it led to some of the most far reaching developments in the civilized world. At once it provided a device on which to build the entire present system of electrical communication, wire and wireless, telegraph, telephone, picture transmission and before long television. It has revolutionized the motion picture industry and given us the modern public address system. And in countless other fields it continues to improve and revolutionize operations and technique.

At first De Forest merely introduced a third electrode into the tube which, by virtue of its proximity to the other elements affected the current through the tube. This was in 1907 and this was the basis of his patent No. 814,387 taken out in that year. In 1908 however he gave the third electrode the form of a grid placed in the space between the cathode and the plate. This idea is incorporated in patent No. 879,532, and is the fundamental principle involved in all electron tubes today.

[3]U. S. Patent, 803,684.

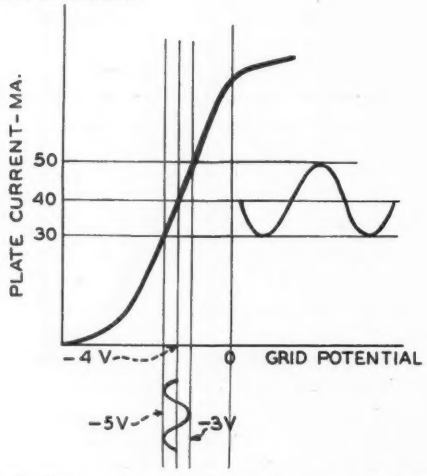


Fig. 12. In this instance a 4 v battery is used to shift the operating point to the proper place on the curve for undistorted amplification

Energetic Jets

FEW MATERIALS have ever appeared so unpromising from a utilitarian standpoint as the recently discovered element deuterium, better known as heavy hydrogen. So much like ordinary hydrogen that refined experiments are required to show any difference, and costing even now thirteen thousand dollars a pound (to be compared with nine cents a pound for hydrogen) it seemed destined to remain a laboratory curiosity, yet an important use has been developed for it.

It has been found possible to produce jets of deuterium gas of such high velocity that the energy available due to speed alone in one pound of the gas is equal to that obtainable from the combustion of two thousand five hundred tons of coal. The apparatus for producing the jets resembles a short-wave radio transmitter operating between the poles of a powerful electromagnet. When the jets impinge on various substances, profound changes occur and artificially radioactive bodies are produced. In particular, samples of common salt have been so far converted as to have a radioactivity half as intense as that of pure radium, and to give off more penetrating gamma rays (short X-rays) than any naturally occurring radioactive substance. The great difference between the radioactive salt and radium is that the activity of the salt decays rapidly and becomes unappreciable after a few weeks, while that of radium continues practically undiminished for centuries. When radium decays it leaves a residue of radioactive substances, but radioactive salt decays to common salt with a little harmless magnesium chloride.

These properties of radioactive salt lead to the possibility of an important medical application. It is very dangerous to introduce radium compounds into the blood for relief of suffering, as there is no good way of getting rid of radium afterward, and prolonged exposure to radioactivity is dangerous. By this new development, however, it may prove possible to give radioactive salt by mouth or injection and obtain the beneficial effects of radium without the dangers.—ARTHUR D. LITTLE, INDUSTRIAL BULLETIN.

ELECTRIC POWER used by the Ford Motor Co. in the Detroit area during 1935 amounted to 658,247,947 kw-hr. representing a value of more than $5,000,000, it was announced at the home offices of the company in Dearborn. Of the company's total usage of electricity in the Detroit area, 645,866,091 kw-hr. was generated and consumed in the Rouge plant; 3,541,000 kw-hr. was purchased from outside sources for use at the Rouge plant; and the remaining 8,840,856 kw-hr. was generated and consumed at various Ford factories in the area surrounding Detroit. In generating the company's requirements of electricity for the year, the equivalent of 747,486 t. of coal was used—enough to fill 19,000 50-t. railway coal gondolas.

A NEW METHOD *of* WIRING Panels *and* Equipment

BY A. E. ANDERSON

Switchgear Division
General Electric Company
Philadelphia, Pa.

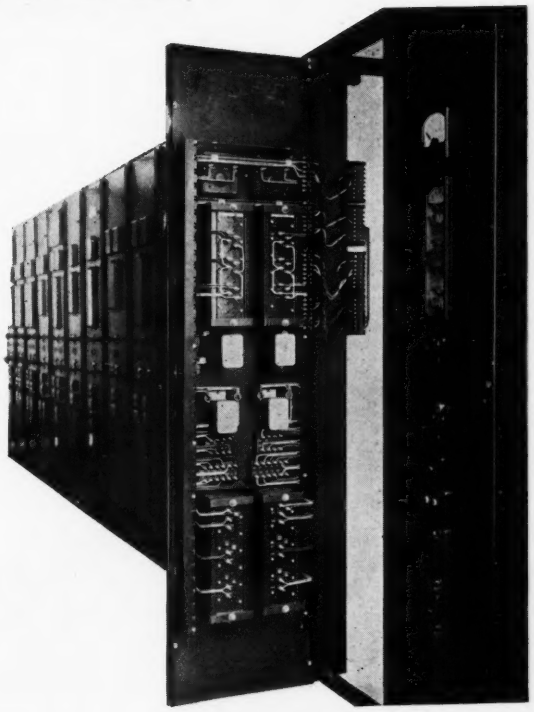


Fig. 1. Semi-flush switchboard consisting of swinging panels

THE INCREASED COMPACTNESS of the modern switchboard has resulted in a greater bulk of small wiring on the back of panels, and with it, the need of a method which utilizes a minimum amount of space, without the sacrifice of the usual facilities for maintenance and inspection. Although panels are in the majority, nevertheless it is desirable to have a method which is also applicable to other forms of switching structures, such as cubicles, switchhouses, enclosing cases and metal clad switchgear. Furthermore, such a method should be adaptable to stationary or swinging panels, wired with solid or flexible wire, and to the various panel materials, such as steel, compound or slate.

After full consideration of the above factors and others entering into the manufacture, installation and operation of all common forms of switchgear, there was developed the method of wiring and assembly here described. This method has now been applied to all forms of power switchboards and switching equipments, and the soundness of the method has been verified by manufacturing and operating experience.

The limiting dimension of a panel or switchboard is usually found to be the width rather than the height. Since groups of vertical wires must be carried between the top and bottom of the panel, it is essential that these groups do not take up valuable panel space, or interfere with the accessibility of back-of-board devices. The new method utilizes either one or both of the borders of the panel which provide zones where the long runs of wires may be carried vertically with the minimum amount of inconvenience.

In using the wiring areas at the borders of the panel it is desirable to provide some means of support where the wires change from the vertical to horizontal runs. Since it is difficult to predetermine accurately the position of each cross wire, it is necessary to furnish a form of support providing a choice of numerous wire positions. The perforated wiring support illustrated in Fig. 1 meets these requirements. It is located at the border of the panel and forms one side of a vertical wiring enclosure. The panel forms a second side of this enclosure, while the flange (of a steel panel) or angle iron support (of panels of insulating material) forms the third side. A removable cover, built in sections, completes the enclosure. When panels are mounted on pipe supports the cover is L-shaped, one side extending to the panel surface, providing one side as well as the top of the wiring enclosure. Since the flange of the angle iron is not as deep as the flange of a steel panel, it is necessary to use a short "L" on those covers used with angle iron supports, the short side of the cover fitting inside the flange of the angle iron. There are a number of other arrangements. However, these are basically the same as those described.

The perforated wiring support is made of steel. The holes, through which the wires are passed, are extruded and rounded so as to be continuously smooth where they come in contact with the insulation on the wires. This series of holes also provides a convenient method for mounting the numerous back-of-board devices, such as resistors, fuse and terminal blocks, reactors, copper oxide rectifiers, etc. No drilling or tapping of the wiring support is required in order to mount these devices.

The cross-section of the wiring support is in the shape of a Z bar with short flanges. The two flanges serve to stiffen the support and also afford means for fastening it to the panel and for attaching the cover. The lower flange (Fig. 2) is provided with a series of slots for the studs or screws which attach the support to the panel. A series of holes in the upper flange is provided for attaching the cover. The slots in the lower flange of the wiring support and in the cover, provide a certain amount of tolerance in the location of these parts.

A number of studs or screws, located at designated points, provide means for holding the support firmly in place on the panel. The sectionalized covers overlap

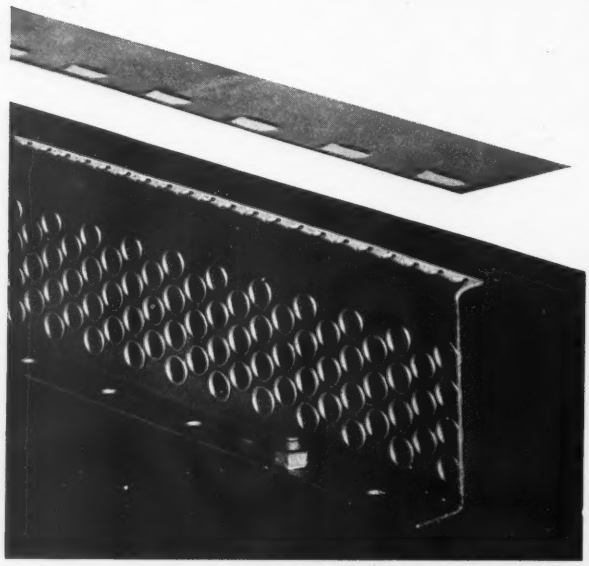


Fig. 2. Perforated steel wiring support showing extruded and smooth-edged holes for panel wires. Support mounted on steel panel. Cover raised

each other, and, as in the case of steel panels, they overlap the flange of the panel, eliminating light openings between panels. The covers are made of thin steel which enables them to be deflected easily where they overlap each other.

When the panel drilling templet is being made, a duplicate copy is obtained, and this copy, showing the location of studs, openings and other data forms the basis of a wiring templet of full panel size. On the wiring templet are shown the locations of the panel wires, miscellaneous back-of-board devices, wiring and other supports, terminal blocks—in fact all of the information that the wireman requires in order to make up the complete wiring for the panel. One such templet is made for each panel or kind of panel in case there are duplicates.

The templet is placed on a table as shown in Fig. 3 and the wiring supports and other hardware are applied as called for on the templet. The studs or terminals of the various devices that are mounted on the panel are represented by dummy studs (whose sizes agree with those of their respective devices) driven into the table top or else full-sized dummy devices are used, such as control switches, test blocks, etc. The net result is to have all of the terminals in their relative locations without requiring the panel or the devices mounted on the panel. Field switches, rheostats and similar back-of-board devices are not represented by dummy devices, but connections to them are provided by looping a designated length of wire at a specified point, and connections to these devices are made after mounting the wiring support on the panel.

After the back-of-board arrangement has been assembled on the wiring templet, the wireman proceeds to make connections between the points specified. The templet is provided with a system of marking which enables him to find quickly the proper terminal points of each connection. Wire loops are made at each dummy stud and the wire is carried across the face of the templet at right angles to the wiring support. It is passed through the support and proceeds either up or down and then out of one of the perforations to the proper terminal, where it is cut to length and a loop formed at the stud. If the wire is carried to a terminal block, a permanent connection is made, since the block is permanently fastened to the wiring support. Permanent connections are also made to indicating lamps and other small miscellaneous devices that

Fig. 3. Table wiring of semi-flush switchboard panel, showing wiring templet, supports and dummy devices

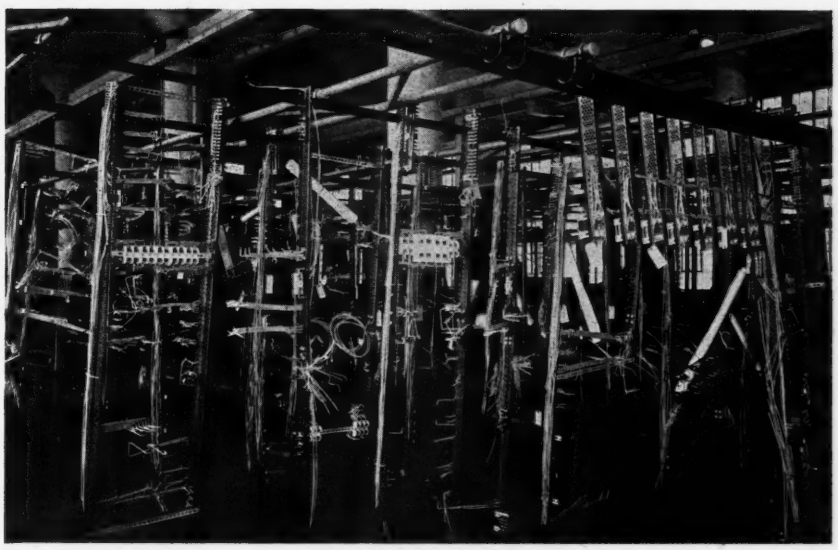


Fig. 4. Perforated wiring supports complete with wire, terminal blocks, etc., stored on racks pending application to associated Switchgear panels

are readily available and can be mounted on the wiring support.

Short connections or jumpers are carried directly between their terminal points, without passing through the wiring support. Such connections are grouped together and banded, where necessary, at frequent intervals so as to stiffen the group, thereby holding the connection firmly in place. Wherever possible they are placed flatwise on the panel. Such an arrangement provides a means for readily tracing the wires across the face of the panel.

The number of holes in the wiring support is far greater than that required for the usual panel, thus providing for additions or changes in wires. There are occasions where an extension is required, usually due to an increased depth of the panel flange or other structural requirements. Such an extended support is shown in Fig. 3 which is to be applied to a semi-flush panel.

After the connections have been made in accordance with the wiring templet, the wiring support, together with associated wires and devices, is removed from the table and hung up on a storage rack. Each wiring assembly bears the identification of its corresponding panel. Fig. 4 shows a number of wiring supports hanging on the storage racks, awaiting the assembly of their associated panels. The miscellaneous jumpers can be seen, grouped together and temporarily tied to the support.

Thus the entire panel wiring is completed even before the panel has made its appearance on the assembly floor, and without the presence of the devices mounted on the panels. As fast as any panel, or group of panels, of a switchboard is ready for its small wiring, it may be sent through the assembly line and the wiring applied without waiting for other panels of the board which may be lacking part of this equipment. It is evident that production peaks will thus be ironed out and that the time required for complete assembly of the board is shortened. Since the drilling and wiring are made from duplicate templets, the support and wire connections will fit readily into position. Then the jumpers are assembled to the proper terminals.

The arrangement shown in Fig. 4 is typical of this method of wiring when used with the conventional switchboard consisting of panels of insulating material mounted on angle-iron supports. Occasionally it is necessary to use a modification of this method, particularly in the case of connections between instrument transformers, circuit breakers, mechanisms and other units in cubicles, frameworks, metal-clad switchgear and trucks. In the latter applications the connections can usually be grouped together and carried through grommets or similar forms of wiring supports.

This method of wiring has been of the greatest utility in connection with the new standard semi-flush switchboards introduced by the General Electric Company. In these new switchboards, practically all front-of-board apparatus is semi-flush, extending only a fraction of an inch from the front panel surface, and so of necessity, meters, instruments, relays, etc., extend beyond the back of the panel. To wire them neatly by the old scheme would be very difficult, but the new method fits in admirably because the wires can be brought through the perforated supports at the proper levels for connection to apparatus projecting considerable distances to the rear. Fig. 1 illustrates the application of this wiring method to a semi-flush switchboard, utilizing a swinging steel panel. This arrangement not only results in a pleasing appearance but requires a minimum amount of installation space without sacrificing accessibility. In this case the wiring supports (and cover) are mounted on both the left and right-hand borders of the door. The door is hinged on the right-hand side (viewed from the rear) and the right-hand support carries a terminal block to which the solid wires (from the panel) and flexible wires (across the panel hinge) are fastened. The other ends of the flexible wires are carried to a terminal block mounted on the side sheet of the enclosure. The flexible wires are grouped, usually in fours, and each group is carried through a grommet mounted near each terminal block, thereby minimizing the strain exerted on points of the terminal block.

In the more complicated control units it is some-

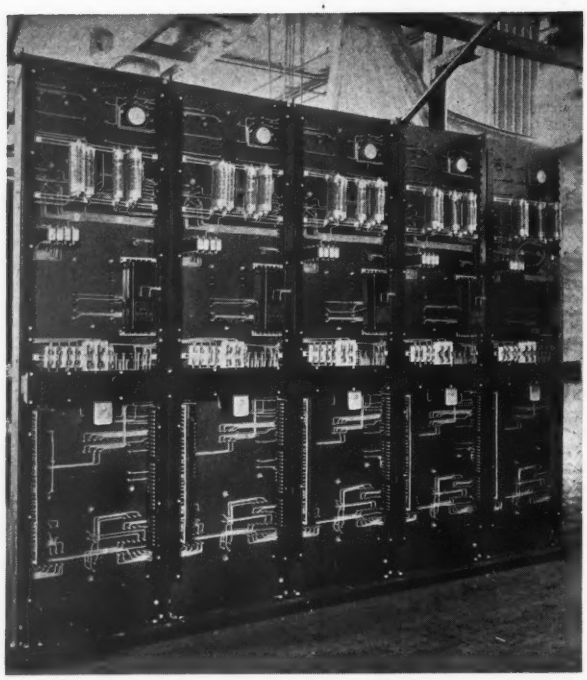


Fig. 5. Switchboard Compound panel, angle iron supports, vertical wiring supports and horizontal cross-trough extending the full length of switchboard for interconnections between panels

times necessary to carry a large number of interconnections between panels. The solution of this problem as shown in Fig. 5 has been obtained without sacrificing the original thought of the panel as being the unit. Such connections are made through a horizontal cross-trough which is pre-wired from a templet in much the same manner as the vertical wiring support. Connections to the wires in the cross-trough are usually grouped, so that a number of larger holes (obtained by knockouts) located along its rear face provide the means of carrying these wires into or out of the trough. After the knockout is removed, a grommet is placed in the hole, thereby protecting the wires from contact with sharp metallic edges. The trough is sectionalized and extensions can be readily made after installation. The connections are so made that the cross-trough may be removed for shipment and the wires, which are suitably identified, can be readily slipped on their designated terminals during installation.

Wires in the vertical or horizontal enclosure may be traced visually, after removing the cover, or in a dense arrangement may be traced by slightly moving the wire.

In case of burnout after installation, the complete new wiring (including vertical and horizontal runs) can be made at the factory, using the arrangement drawings of the original equipment. In this form it can be readily assembled on the panels in the station.

Correction Note—Hypothenuse Determination by the Slide Rule Method

IN THE SECOND EQUATION on page 249 of the April issue, the second term under the radical should be multiplied by the first term and not added to it. This equation should read: $R = \sqrt{(a^2 + b^2) \times a^2/a^2}$.

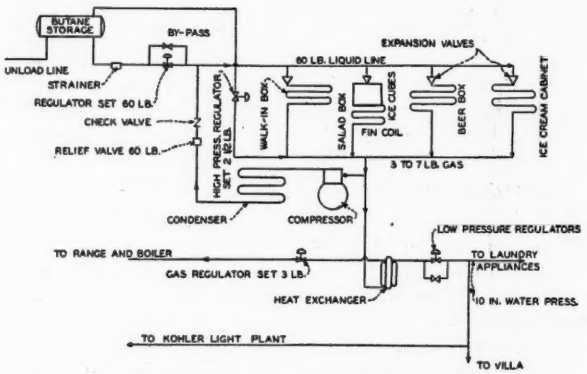
Butane—The Complete Fuel

By Harry Sherman

AT JUNE LODGE, a resort hotel in California, butane, made from oil well casing head gas, is used as fuel for heating, cooking, power purposes, automobiles and, strangely enough, for refrigeration purposes in an expansion system. This volatile fuel, liquid under pressure, is stored like gasoline and sells for about six cents a gallon (minus the tax) in Los Angeles.

At the hotel the consumption for two hot air furnaces in the main building, heating 22 cottages, bathhouse, refrigeration, hot water, cooking, laundry and electric light plant, runs from 75 to 100 gal. a day. The installation, although entirely new, has proved practical and a diagrammatic arrangement of equipment is shown by the drawing.

The fuel is blended with 25 per cent propane, 50 per cent isobutane and 25 per cent n.butane. Leaving the storage tank at 60 to 80 lb. depending on the tempera-



Diagrammatic layout of Butane system used at California Resort

ture, the pressure is reduced to 60 lb. and, in normal service, the butane flowing to the burners is expanded through refrigeration coils placed between the liquid line and 3 to 7 lb. gas line as shown.

To maintain refrigeration during periods of little or no fuel consumption a compressor driven electrically from the lighting plant, is provided and is cut in automatically so as to maintain a pressure of 3 to 7 lb. in the suction line. From the compressor the gas is liquefied in a water cooled condenser and returned to the 60 lb. line. An auxiliary regulator keeps this pressure from falling below 2½ lb. during low refrigeration and high heat demands. The range and furnaces are equipped with 3 lb. burners while the laundry, miscellaneous appliances and Kohler engine-generator set operate from 10 in. w.g. pressure. An installation of this kind is said to cost from $2000 to $3000.

FOR REFINING a 42-gal. barrel of crude oil, 554,000 B.t.u. are used up in the process.

Rapid Repair Work Speeds Flood Recovery

Fig. 1. Muddy motors were thoroughly cleaned with high pressure fire hoses to remove slime and refuse before being reconditioned at Westinghouse's Renewal Parts Plant

THE RECENT DESTRUCTIVE FLOODS in the Eastern part of the United States brought forth many interesting examples of man's resourcefulness in times of emergency, and, by its absence, demonstrated in a rather ironic way, our great dependence upon power. For, while other services were missed, the greatest need was for power, and when, in Pittsburgh, the power stations finally had to close down, the situation became serious indeed. Tragic as the situation was, there were many interesting incidents which indicated man's ability to overcome obstacles however great they may be. Manufacturing plants, transportation companies, public service companies, all coöperated in splendid fashion to bring about a resumption of normal activities and in many instances this restoration was carried out with remarkable dispatch.

Isolated plants, in particular, proved exceedingly useful. In Pittsburgh the Boggs & Buhl department store across the river on the north side supplied the telephone company with power from their private plant. The Jones and Laughlin Steel Co. building which has its own power plant rendered similar service in supplying current to the city fire department, indeed had it not been for this connection the city would have had no fire alarm system.

The public utility companies made every effort to maintain service. The West Penn Power Co., realizing that they would have to keep their plant in West Virginia running at all costs, entrenched themselves by welding the edges of the steel doors, welding manholes and calking up and nailing all wooden doors. They arranged to take coal in at the third story window so they could keep running.

Knowing furthermore that they would be isolated for several days at least, they sent two trucks down town and by way of introduction informed a certain Greek restaurant proprietor that he would be wiped out by the flood. Then they offered to move him, bag and baggage, to the power plant and pointed out that, there, he could serve food and thus save his equipment and stock. Needless to say, he accepted with alacrity and so the power plant crew was able to eat.

Diesel engines and other internal combustion engines were very much in demand, and unexpectedly students at the Jourdan Diesel Schools in Pittsburgh found themselves "men of the hour" as frantic merchants and business men in the flooded "Triangle" sought to clear out basements and cellars. Every Diesel engine used for experimentation in the school was put to work.

In some instances, internal combustion engines were used to drive stokers. As shown in the accompanying illustration, small gasoline engines were collected from concrete mixers and rigged up through pulleys and belts to drive pumps and stokers. The illustration shows one of these engines in the heating plant of the Berger Building in Pittsburgh, driving the Combustion Engineering Co. stoker under a 150 hp. Heine boiler.

The electric manufacturing companies did splendid service in restoring damaged electrical equipment to operating condition, indeed water, electric power and communication facilities were restored hours in advance of normal expectancy as a result of their prompt action. Both the Westinghouse and General Electric service shops in the affected area were kept busy day and night taking care of emergency orders resulting from flood damage.

Because of special production facilities and trained personnel for renovating flooded equipment in minimum time, the city engineer of Pittsburgh and the local utility extended Westinghouse every coöperation. The electric company furnished 500 kw. twelve hours after the general power failure while Pittsburgh remained in darkness and the city placed the plant on the same schedule as hospitals for water to supply steam for the drying ovens. Hours before the flood reached its crest of 46 ft. (midnight, Wednesday, Mar. 18) Westinghouse constructed 9 drying ovens by candle light, formulated a repair schedule for large utilities and industrial plants to prevent swamping facilities, set 450 trained employes working in two 12-hr. shifts.

At the Pittsburgh shops of the General Electric Co. some 34 experienced repair men were added to the force, these being sent from Schenectady, Chicago, Cleveland, Newark, New York and Buffalo construction forces; a half dozen went to Hartford; others to the New England district. The Schenectady, Lynn, Philadelphia, Pittsfield and other plants had forces available over the week end to care for rush shipments of motors, transformers and other complete equipment for parts and for work on emergency repairs.

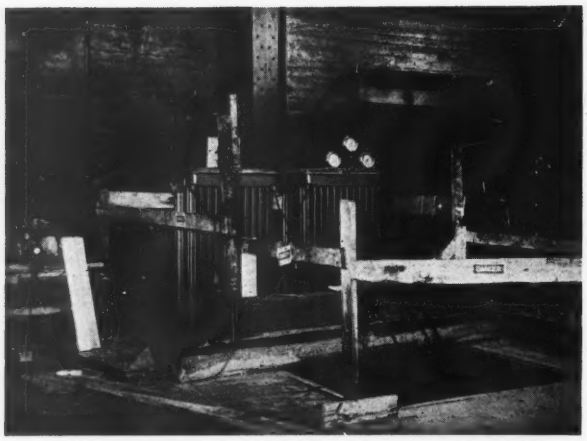


Fig. 2. Before the first turbine generator in this flooded Pittsburgh power house could be started it was necessary to install a bank of 150 kv.a. 2300 v. transformers to provide power for the auxiliary pump motors. After the turbine was up to speed the motors were transferred to the generator bus. (Westinghouse photo)

At the Westinghouse plant, during a three day period (the week end of Mar. 21) about 1500 units arrived for repair. Motors, circuit breakers, coils, regulators, control boards, etc., were being received at about 500 units per day. Working day and night the plant turned out about 200 finished and tested units every 24 hr. This rapid service was the result of 17 special drying ovens, some electrically heated and others heated by steam where electric power was not available. The special vacuum type ovens maintaining 95 to 110 deg. C. dried out 25 stators and 25 rotors in 6 hr. compared to 16 hr. required for conventional repair shop ovens. New coils for motors were wound on the spot as were solenoid closing coils for circuit breakers and coils for regulating devices. Motors formed the bulk of the damaged equipment and ranged in size from ¼ hp. for a regulator to 400 hp. for a boiler feed pump at a local generating station. Where it was impractical to bring equipment to the plant, experts were sent to do the jobs on location. One hundred steam specialists were rushed from Westinghouse's Philadelphia plant to aid in servicing generator units and their auxiliaries.

Fig. 3. The main field rheostat on one of the 25,000 kv.a. generators in a Pittsburgh power station was entirely submerged. Here a bank of 3 portable electric heater type blowers is being connected to dry out the rheostat. (Westinghouse photo)

Although the General Electric service shop at Pittsburgh had a maximum of 10 ft. of water on the first floor at the height of the flood, by Mar. 20 the water had receded so that operation of the ovens could be started.

One of the interesting services was in connection with a short-wave radio appeal, asking for a 120-hp. induction motor required for the pumping station of the town of Tarentum, Pa., in the Pittsburgh area. A G. E. employe at Schenectady heard the appeal at his home Saturday afternoon. He notified the G.E. office in that city, contact was established with Tarentum and the need confirmed; and the required motor was promptly sent from Schenectady by truck.

Four drums of Transil oil were delivered to a customer at Johnstown, Pa., as the result of another radio appeal. The call was heard by Station W8DYY at Cleveland, and a telegram sent from there to Schenectady. That office knew the oil was in stock at Cleveland, so telegraphed to that city. It was shipped from there to Johnstown the same day.

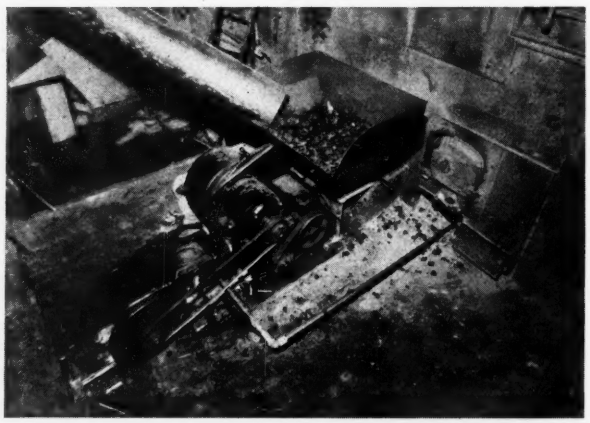


Fig. 4. Improvised stoker drive supplies heat during flood. Small gasoline engine from concrete mixer installed to drive stoker in a Pittsburgh building. (Photo courtesy Combustion Engineering Co.)

A hospital at Hartford, Conn., appealed for a generator—it had only two lanterns. A 150-kw. generator was located at Schenectady, loaded on a truck that night, and delivered for service at 3 a. m. next morning.

There were numerous instances where submerged motors were received at service shops Friday night and delivered on Sunday—after being disassembled, cleaned, dried out, treated with insulating varnish, and baked.

In addition to the many jobs which were cared for in the G.E. shops there were, of course, even more which were attended to by the utilities and industrial plants themselves. Hundreds of letters were sent out by the G.E. to industries in the flooded areas, giving recommendations on the servicing of equipment which had been submerged—telling how to dry out motors, how to give direct current motors their particular treatments, how to replace oil in transformers, etc. Radio, too, was pressed into service, with announcements broadcast so that those facing emergencies would know that service was available through the week end, and through the 24-hr. day.

As One Engineer to Another—

Some Fundamental Principles of Air Conditioning Come in for Discussion as G. F. and the Chief Continue the Study of Air for Human Comfort and Industry.

By G. F. WETZEL

"WELL, Chief, this spring weather seems to have given you the well known fever," I remarked as I walked into his office and caught him gazing out the window at the slow moving cumulus clouds.

"Now, was that nice? If I must know air conditioning I want to study the ways of a past master of the art. What you can give me is only second or third hand, but I am not too proud to pick up facts I need from any source."

"That is really a fine spirit, Chief, and just what I expected for the trouble I took to post myself on the latest thoughts in air conditioning. I did find something, however, that will interest you. Here are four fundamental principles of air conditioning which will give you some information and something to think about:

(1) When dry air is saturated adiabatically, the temperature is reduced as the absolute humidity is increased, and the decrease of sensible heat is exactly equal to the simultaneous increase in latent heat due to evaporation.

(2) As the moisture content of the air is increased adiabatically, the temperature is reduced simultaneously until the air is saturated, when no further heat metamorphosis is possible. This ultimate temperature is called the temperature of adiabatic saturation.

(3) When an insulated body of water is permitted to evaporate freely in the air, it assumes the temperature of adiabatic saturation of that air, and is unaffected by convection, that is, the true wet bulb temperature of the air is identical with its temperature of adiabatic saturation.

(4) The true wet bulb temperature of the air depends entirely on the total of the sensible and latent heat of the air, and is independent of their relative proportions. In other words, the wet bulb temperature of the air is constant provided the total heat of the air is constant.

"From these principles you can see the importance of the wet bulb temperature, and it is this temperature you use to find the total heat of the air if you refer to a table of the properties of dry air mixed with water vapor. For example, if the wet bulb temperature were 60 deg. and the air saturated, the total heat would be 26.18 B.t.u. above 0 deg., computed as you did it a little while ago. Now, if we keep the wet bulb at 60 deg. and the dry bulb temperature increases to, say, 100 deg., the total heat in the air would be the same because, as we see from the fourth principle, if the wet bulb temperature is constant, the total heat is constant and depends entirely on the total of the sensible and latent heat of the air. The relative proportion of each has no effect, with constant wet bulb temperature. As the sensible heat of the air increases, when its temperature goes up to, say, 100 deg., the weight of the moisture per pound of dry air decreases in exact proportion, so that up to the point where there is no more moisture, and consequently zero latent heat, the total heat will be unchanged with changes in dry bulb temperature."

"Sounds rather involved to me, G. F., but I guess if I take time to think it over it will get straightened out. And what does adiabatic saturation mean?"

"Adiabatic means without change of heat content. You have heard of the adiabatic expansion of steam in an engine cylinder: the original heat content does not change, but the distribution of energy changes, some of the latent heat changing to its heat equivalent of mechanical work, with consequent partial condensation and reduction of pressure. Adiabatic saturation in air conditioning means a heat exchange from the sensible heat of the air and sensible heat of the water exposed to the air to supply the latent heat of evaporation to evaporate a certain amount of the water, with a consequent drop in temperature of the air. The greater the existing vapor pressure (or relative humidity) the less water will evaporate, and the less the cooling effect and drop in temperature, or the higher the wet bulb temperature, until with fully saturated air, the dry bulb, wet bulb, and dew point temperatures are exactly the same."

"I've got a couple of questions, G. F.," the Chief interrupted. "Give me a clear definition of relative humidity, and explain the significance of 'dew point'."

The Meaning of Relative Humidity

"Relative humidity is usually described as a ratio of the moisture the air actually holds compared with what it could hold at the same temperature, but air does not hold any moisture, and therefore this definition is not scientific. Humidity has nothing to do chemically with the air, the vapor merely mixes intimately with air, sharing the same space with the air, and every question about humidity can be answered by the principles of steam and water vapor, which, as I have said a number of times before, are the same thing. Relative humidity is a ratio of the existing vapor pressure to saturated vapor pressure at the same temperature. It is also defined as the weight of vapor in

a given space compared to weight of saturated vapor the same space could hold at the same temperature.

"There is a slight discrepancy in these two definitions, if you supply the values and calculate each one numerically, but at the temperatures used in air conditioning work, this is not serious. Keep in mind that air is dry and consists of oxygen and nitrogen with negligible amounts of other gases, but it has mixed with it various amounts of water vapor, so that though we say the air is moist or dry, or the humidity is high or low, we really mean that the vapor mixed with air is greater or less in amount. Another way of describing the condition is to say that the vapor mixed with the air is superheated a greater or less amount, which brings us to 'dew point'.

"Dew point is merely the saturation temperature at which vapor will condense when the superheat is removed. To illustrate, the temperature here in your office is 70 deg. We will say that the vapor is superheated 20 deg., which would make the saturation temperature or dew point 50 deg. Therefore, the amount of moisture in the air is exactly the same per pound of dry air that there would be if the air were at 50 deg., mixed with saturated vapor at 50 deg. Now, it would be interesting to compute the relative humidity based on vapor pressures for 70 deg. with a dew point of 50 deg. Go ahead, Chief."

So he looked up vapor pressure at 50 deg.—0.3624 in. of mercury, and at 70 deg.—0.7387, and figured relative humidity as their ratio:

R. H. $= 0.3624 \div 0.7387 = 0.492$, or 49.2 per cent.

Comfort Zone

"Relative humidity is extremely important, in fact, relative humidity and dry bulb temperature are the two characteristics that govern comfort, and the conditions required for certain industrial operations and processes. For comfort conditioning relative humidity should be kept between 30 and 70 per cent. For winter conditions, a humidity above 40 per cent will cause excessive frosting of windows not protected by storm windows, and may even cause condensation on walls with consequent damage to decorations. It has been found from experience that as the relative humidity becomes less, a higher dry bulb temperature must be maintained for the same comfort as to temperature, but as the humidity decreases, even with a high dry bulb temperature, a feeling of dryness will be apparent, both on the skin and the mucous membranes of nose, mouth, and throat.

"The Guide of the American Society of Heating and Ventilating Engineers shows a Comfort Chart with summer and winter comfort zones. For winter comfort, the effective temperature range is from 63 to 72 deg., with a relative humidity of 30 to 70 per cent, and for summer comfort the effective temperature range is 66 to 75 deg. with same humidity range. The most comfortable part of these zones for most people has not been determined. When we are dealing with anything as intangible as comfort, it is extremely difficult to pin it down to definite figures."

"Now you have sprung a new one on me," the Chief interrupted again. "Just what, pray tell, do you mean by 'effective temperature'? You have been talking about dry bulb temperature, wet bulb temperature, dew point temperature, and now another one. I think I'll stick to my own knitting, and let this air conditioning stuff alone."

"You think you will, Chief, but how do you know that the office of your own plant, or some of your manufacturing processes will not be air conditioned within the next year or two. Or you might even get a better job, if you knew something about air conditioning, or changes might come about that would compel you to make a change in position, so don't limit yourself.

Effective Temperature

"Your question about effective temperature is a good one. This is an arbitrary index of the degree of warmth or cold felt by the human body in response to temperature, humidity and air movement, combining the effect of these factors into a single value. The comfort zone values are for an air movement of 15 to 25 ft. per min. which is classified as still air. Effective temperature is based on the temperature of saturated air which will give the same feeling of warmth or cold as the given combination of dry bulb temperature, relative humidity and air motion in any given space.

"To give the comfort zone limits in terms of dry bulb temperature and relative humidity, the summer zone takes in 72 to 85 deg. at 30 per cent R. H. (relative humidity) and 68.5 to 78.5 deg. at 70 per cent R. H. The winter zone includes 68 to 79 deg. at 30 per cent R. H. and 65 to 74 deg. at 70 per cent R. H.

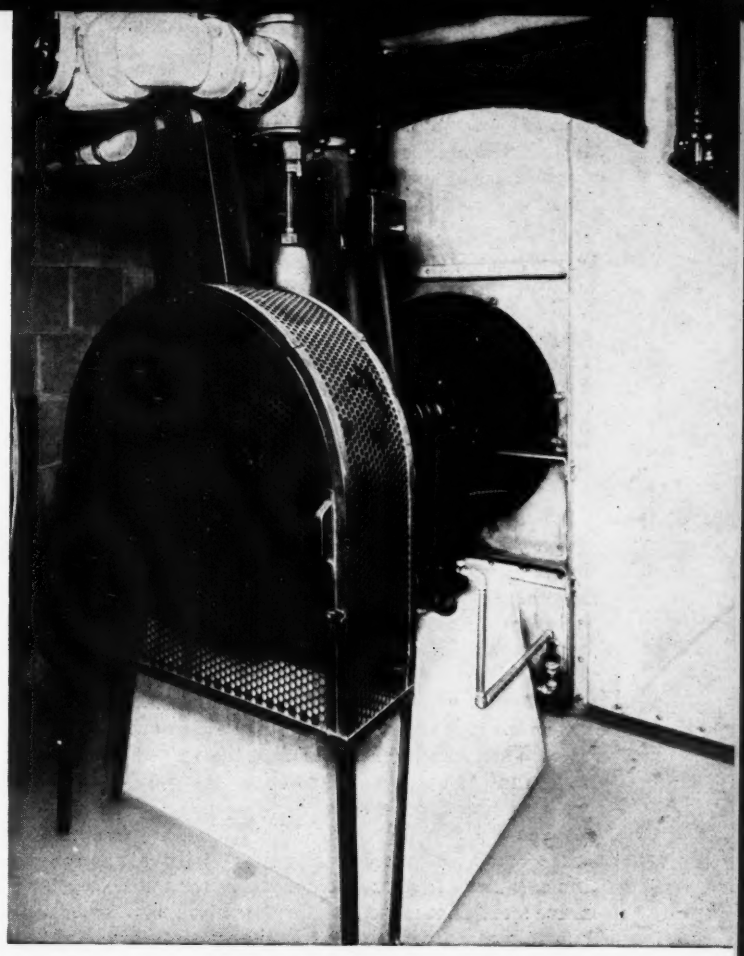
"When you get into the subject of comfort, there are so many variables and considerations that we could spend hours discussing it, especially if we got into the physiological effect of temperature and humidity, and the mechanics of control of body temperature. The important factors are length of exposure, activity of occupants, average conditions desired, and extreme conditions allowed. For industrial processes, the conditions are usually fixed between rather definite limits by the nature of the process, such as paper making, printing, textile work, tobacco products manufacturing, baking, etc.

"I am afraid we have rambled around a bit this time, Chief, but I hope our little discussion gave you an inkling of what air conditioning means. The whole heating, ventilating and cooling industry is going through a state of rapid development and change because of the public demand for air conditioning, and there is no telling how far it will go in the future. Well, I must run along now. If you want to go a little further into some of the phases of air conditioning, give me a ring or let me know next time I see you."

According to Electrical Research Statistics, released recently by the Edison Electric Institute, the cost of electricity in the home has followed its long continued downward trend and is now below 5 cents per kilowatt-hour. For the twelve months ended January 31, 1936, the average price paid for domestic electric service was 4.99 cents, or 43 per cent below its cost in 1913. With the exception of the period of the World War and the years immediately following, when its rate of progress was retarded, the price of electricity for domestic use has declined ever since Mr. Edison established his first central station.

Steam Engines for Industrial Service

Part II. Types, sizes, design and mechanical characteristics of modern engines. By F. J. Vonachen, Troy Engine & Machine Co., Troy, Pa.



FLEXIBILITY, ACCURATE CONTROL, economy and reliability are all essential factors to proper industrial production which are met by the modern steam engine. In variable speed service, it has a wide, smooth, easily adjusted, speed range with infinitely small steps and is well adapted to automatic control. Whether the control is manual or automatic, definite speed is maintained for each point of control. In other words, there is good regulation and, of prime importance, no hunting. Constant speed engines, for example those driving generators, use the automatic governor which gives regulation within two per cent from no load to full load. Steam engines are also quickly started as very little warming-up is required. They can be placed in service very quickly.

As to reliability, the modern heavy duty steam engine is of rugged construction, has been continuously improved and is fully enclosed, self-oiling and oil-tight so it is quite common to have months of continuous service at full load without a shut-down. This is a common experience, for instance in refinery service.

Its speed is conservative and conducive to long life. Compressors, fans, generators, rotary pumps and exhausters may be direct connected. Only a small speed reduction is necessary to drive stokers, cold and hot oil charging pumps for refineries, cookers, mixers, presses, mills, balers and conveyors. Higher speed fans, blowers and driers may be driven by flat or V-belts, or chains. Its high starting and running torque and large overload capacity are desirable features for most installations but particularly so for pumping viscous materials and for operating driers, presses, mixers, conveyors and balers.

Questions are sometimes asked—"Why are these engines modern? How have they been modernized?" First, while the generation of by-product power is not new, more recent are its general application to all industry and an understanding and appreciation of it by most people as an effective means to obtain low power costs. Second, while no radical changes have been made in the basic design of the steam engine, the design has been greatly refined by taking full advantage of high grade modern materials now available and by careful refinement of each part from the standpoint of field requirements.

This refinement has made the modern steam engine simple, foolproof and reliable. It has practically eliminated attention by the operator and when attention is required, it has given him every convenience so that adjustments and operations can be carried out quickly and efficiently. It has substantially reduced steam and oil costs. It has placed the modern steam engine head and shoulders above the older designs and has given to industry an unusually effective, low cost, proven drive for many types of equipment.

Modern steam engines, as made by the company with which the author is connected, are built in single valve, counterflow, double-acting, flat and piston valve, vertical and horizontal, throttling and automatic, single cylinder and duplex types. The single cylinder engines are rated from 1 to 225 hp. The duplex engines are vertical type only, have their cranks at 90 deg. to eliminate dead centers, and range from 1 to 450 hp. Complete generating sets (a.c. or d.c.) are also available in vertical and horizontal types, in capacities suitable for the main load in the smaller plants, and for peak, night, week-end, and holiday loads in larger plants. In addition, they are used as standby power for important processes, to reduce demand charges, as a flexible power source for unbalanced production, for the operation of magnets on locomotive cranes, as emergency units and for the produc-

tion of power and light on board ship. These are built, tested, and shipped as complete units.

Because of space limitation and since all types of engines covered by this discussion are quite similar, only the design of the vertical engines, as shown by Fig. 5, will be discussed here.

All parts of the cylinder, steam chest, piston, and valve in contact with the steam are alloy iron. The cylinders are detachable from the engine frames and fitted with American Standard flanged pipe connections. Recent redesign has greatly improved the previously good economy. The piston which is cored for lightness is easily replaced when necessary as it is pressed with a taper fit against a shoulder on the piston rod and locked by a castle nut and cotter pin.

There is a choice of valve type. The piston type (Fig. 7) furnished with or without rings, is perfectly balanced as it is entirely surrounded by the steam and is generally used for fairly dry, superheated, or high pressure steam. It operates in a replaceable, ground valve chamber bushing with accurately milled ports. This feature makes it unnecessary to rebore the valve chamber as a new bushing can be installed at minor expense. This feature also maintains the original water rate. When furnished with rings, the valve has two narrow rings at each end, thus eliminating difficulty with wear of ring grooves.

The flat type of valve (Fig. 7) is suitable for very wet steam as it automatically lifts off its seat to relieve the cylinder of excess condensation without disturbing valve stem alignment. It is practically balanced, has accurately machined port edges, has very light weight to reduce friction and wear, and is ground to its seat under pressure. A balancing ring held against the steam chest cover by a flat spring eliminates steam pressure from a portion of the back of the valve. The live steam pressure against the remainder of the back of the valve keeps the valve stem tight and automatically adjusts for wear.

The engine crosshead is fitted with bronze shoes grooved for proper oil distribution while the connecting rod has the wide bearing at the lower end fitted with a removable babbitt bushing with laminated shim adjustment. The upper end is fitted with a bronze box with wedge adjustment. The crank shaft, forged steel turned, ground and counterbalanced, is furnished with suitable extensions for pulley, V-belt sheave, sprocket or coupling.

Frame is cast iron and is fitted through machined surfaces with two large panels or doors and two large hand hole plates, all of which can be easily and quickly removed for inspection purposes. These surfaces are grooved to prevent creepage of oil by surface tension or provided with gaskets. Aluminum panels are used in the larger engines to facilitate handling. Oil throws overlap gutters on the panels to positively eliminate oil-leakage along the crank shaft thus removing a serious difficulty experienced with older designs.

Bearings are of babbitt or high grade bronze, all easily adjusted by laminated shims or other simple adjustment. They also have generous adjustment range which permits years of service without replacement. Main bearings are removable without removing the shaft and all others have renewable bushings which are easily replaced if necessary by interchangeable spares.

The lubricating system has a number of features which are very valuable from the standpoint of convenience, reliability of operation and low oil consump-

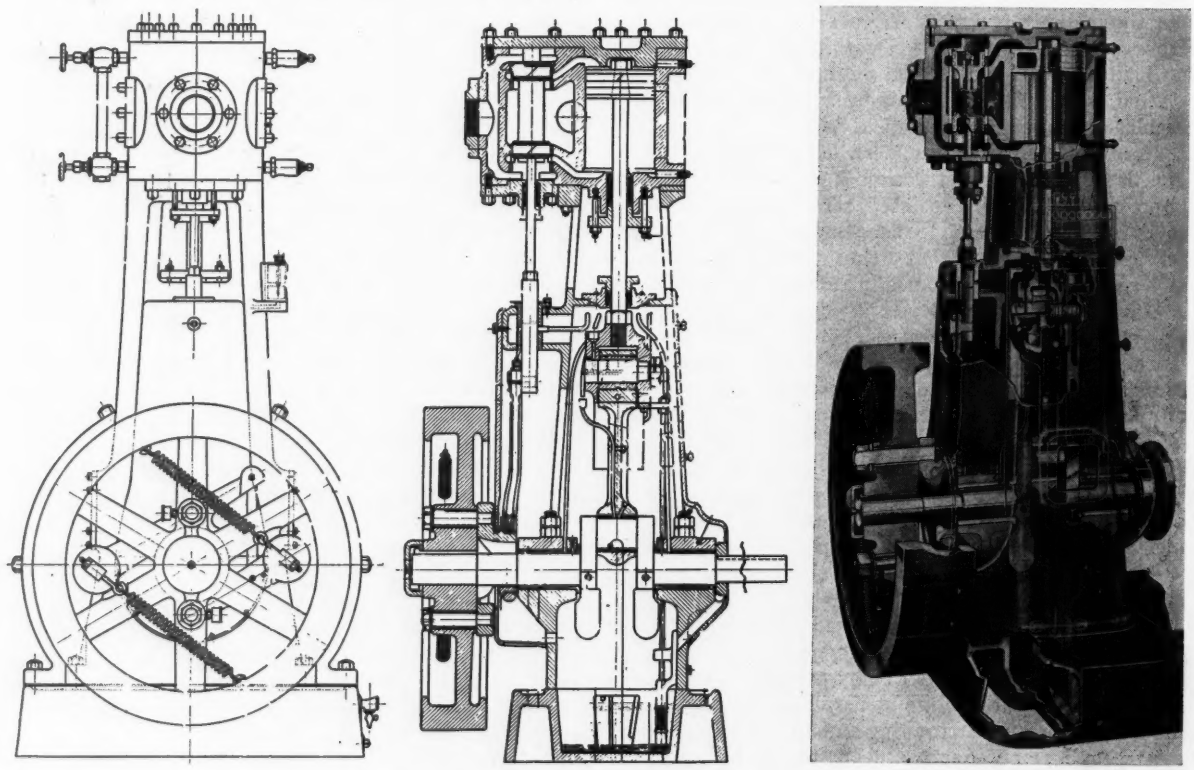


Fig. 5. Elevation and section of a vertical engine

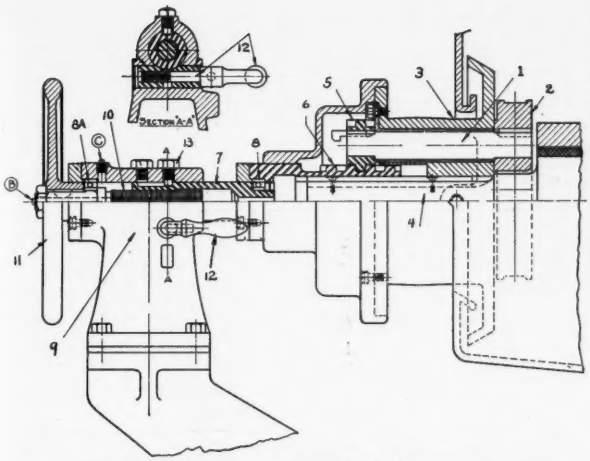


Fig. 6. Construction of the variable eccentric

Eccentric pin 1, keyed to eccentric 2, is supported in the support 3 which in turn is keyed to the crankshaft 4 and locked by a set screw spotted into the shaft. Helical pinion 5 is mounted on the other end of the eccentric pin and secured by a gib key. On the crankshaft, and meshing with this pinion, is a helical gear 6 which can be moved axially on a feather key in the shaft. Axial motion of the gear produces rotation of the pinion, eccentric pin, and of the eccentric about the center of the eccentric pin, changing the cutoff, the lead and the stroke of the valve.

Provision is made for sufficient movement of the gear to allow setting the eccentric to any cutoff from zero to maximum for either direction of rotation of the crankshaft. The eccentric pin bushing 59 has the bore eccentric with the outside diameter permitting an adjustment of the center distance between the gear and pinion, allowing these to be meshed tightly enough to eliminate backlash between the teeth.

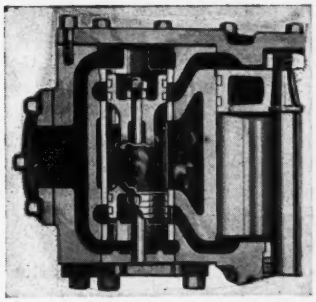
Gear 6 is held in position or moved along the crankshaft by the spindle 7 which does not rotate and is connected to the gear by the ball bearing 8. The other end of the spindle is carried on a feather key in the bore of the pedestal 9 and is threaded internally for the screw 10. The screw is also supported by the ball bearing 8A and is turned by the hand wheel 11 keyed to it.

Fine adjustment of the eccentric setting can be obtained as several turns of the hand wheel are required for a change from zero to maximum cutoff. Although the screw cannot be moved by the gear because of the pitch of the thread, an additional lock is provided as shown by Section A-A. A fraction of a turn of the handle 12 is sufficient to clamp or loosen this lock. Stop screw 13 is provided to limit the travel of the spindle to the length of this slot.

tion. The engine base contains an oil reservoir, separator and automatic water drain and slopes toward a large drain plug, so that it can be easily flushed out and cleaned. The separator and water drain automatically and continually separate and discharge from the base into an outside drain any condensate that may accumulate.

Located in the oil reservoir, the oil pump delivers oil into a distributing oil box on the side of the engine frame. The oil pump has a straight plunger driven from the crosshead, and ball check valves. The distributing box is provided with adjustable sight feeds for all bearings, and is made of aluminum which gives a permanent light-colored background against which the oil feeds are readily visible. From the bearings the oil is drained back into the base, available for further use.

A new type of watershed partition (Fig. 8) provided between the cylinder and crank case, is one of the most important recent improvements made in vertical engines. Sufficient space is provided between watershed and cylinder so no part of the piston rod which runs below the watershed enters the piston rod stuffing box. This prevents bearing lubricating oil from entering the cylinder, a requirement of vital importance for operation without cylinder lubrication and of value in preventing loss of oil. The watershed partition is so trapped and drained that no bearing lubricating oil finds its way to the top of the watershed, eliminating another frequent source of oil loss.



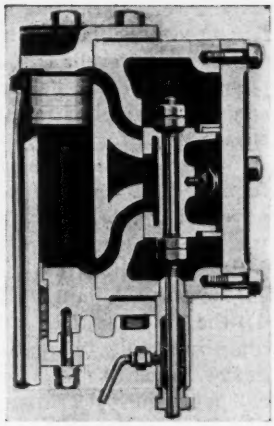


Fig. 7. Types of steam valves used; left, piston type valve, right, flat type

Piston rod and valve stem stuffing boxes are trapped to drain condensate and cylinder oil to the top of the watershed. The watershed is in turn trapped to collect condensate and cylinder oil from the piston rod. A drain is provided on the side of the engine frame to remove this condensate and cylinder oil. An excellent feature of this new watershed design is that no part of

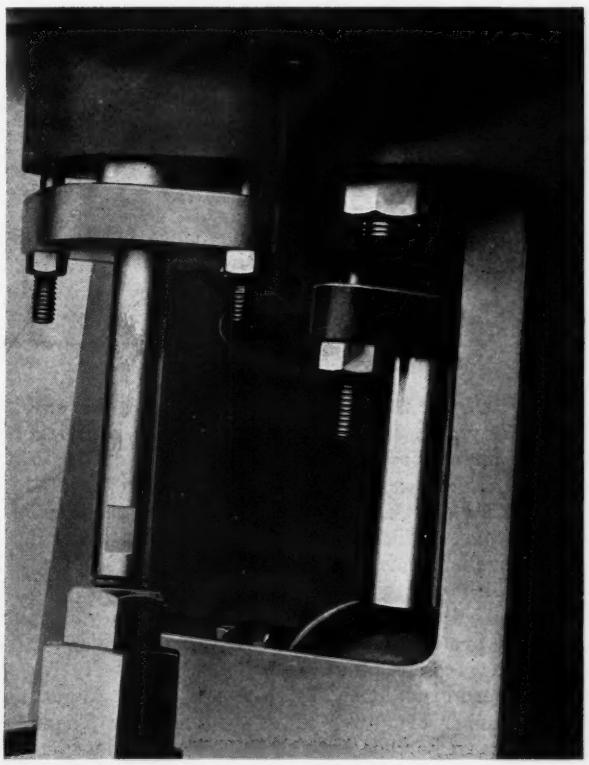


Fig. 8. New type watershed partition between cylinder and crankcase

the piston rod comes in contact with the watershed thereby eliminating wear and the action of wear on the proper functioning of the equipment.

Governors are throttling or automatic type. The throttling type, of proper design and materials for the steam conditions, is used for adjustable speed service, either for manual control or as a maximum speed stop in conjunction with automatic control. With throt-

tling governor, the engine is usually furnished with a fixed eccentric having a fixed point of cut-off. The throttling governor can also be furnished with an attachment that can be directly connected to automatic control, in which case the governor maintains definite engine speed for a particular setting of the control.

For wide speed range this type of governor can be furnished with a V-port valve cage which makes the governor stable at low engine speeds or light loads with the governor valve just cracked. With a hand adjustable eccentric, the cut-off can be varied when the engine is not running. With a variable eccentric (Fig. 6), the cut-off can be varied while the engine is running by simply turning a hand wheel. Both of these devices permit setting the cut-off at the most economical point, thus decreasing the steam consumption approximately 10 per cent below that obtained with fixed eccentric. They also permit reversing the direction of rotation. The automatic or flywheel type of governor automatically adjusts the cut-off for best economy but is suitable only for constant speed service.

Fusible Plugs Improved By New Specifications

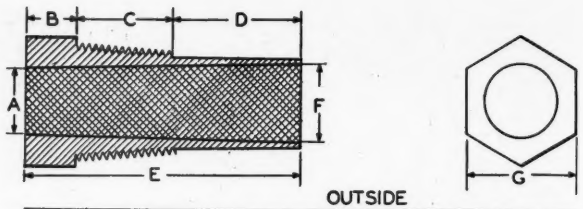
Many failures of fusible plugs in service could be averted by use of new designs specified for marine service.

By C. C. CUSTER

ALTHOUGH the fusible plug is one of the oldest safety devices known, its functioning is not thoroughly understood by many engineers. At its best it is not 100 per cent perfect as a safety device. It may be of wrong design, it may be improperly placed, or improperly maintained, or may deteriorate in use which conditions may cause it to blow too soon, too late, or not at all.

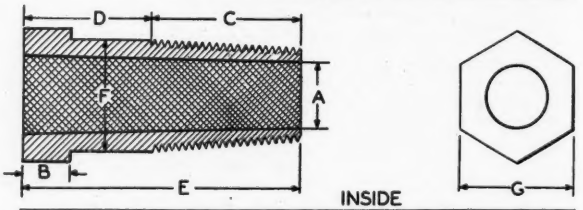
Some boilers are of such design that they cannot be easily protected by fusible plugs, and in some other types the fusible plug is of doubtful value. These points were brought out in an article in the August 1, 1930, number of Power Plant Engineering. The aim of the present article is to show how plugs deteriorate in use, how manufacturers have up to the present made mistakes in building plugs, how designs of plugs may be improved, and what the U. S. Marine Service has recently done to effect improvement of design. The authorities to be quoted are the A.S.M.E. Code, the code of the State of Massachusetts, and the Rules 1 and 2 of the U. S. Dept. of Commerce, Bureau of Navigation and Steamboat Inspection. All the above authorities should be read and compared by any one who wishes to be well posted on fusible plugs.

Figure 1 shows acceptable forms of fusible plugs



OUTSIDE

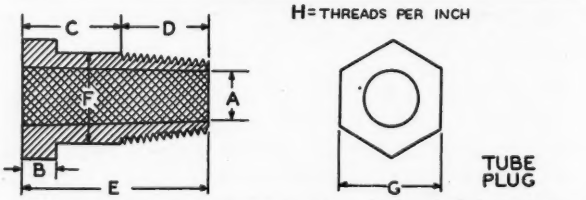
SIZE	A	B	C	D	E	F	G	H
1/2	1/2	3/8	3/4	1	2 1/8	11/16	15/16	14
3/4	1/2	3/8	7/8	1	2 1/4	3/4	1 3/16	14
1	1/2	3/8	15/16	1	2 5/16	25/32	1 3/8	11 1/2
1 1/4	1/2	3/8	1 3/16	1	2 9/16	13/16	1 13/16	11 1/2
1 1/2	1/2	7/16	1 5/16	1	2 3/4	7/8	2 1/8	11 1/2
FOR ALL PRESSURES								



INSIDE

SIZE	A	B	C	D	E	F	G	H
1/2	1/2	3/8	3/4	1	1 3/4	27/32	15/16	14
3/4	1/2	3/8	7/8	1	1 7/8	1 1/16	1 3/16	14
1	1/2	3/8	15/16	1	1 15/16	1 5/16	1 3/8	11 1/2
1 1/4	1/2	3/8	1 3/16	1	2 3/16	1 21/32	1 13/16	11 1/2
1 1/2	1/2	7/16	1 5/16	1	2 5/16	1 29/32	2 1/8	11 1/2
FOR ALL PRESSURES								

H = THREADS PER INCH



SIZE	A	B	C	D	E	F	G	H
3/8	3/8	1/4	3/4	11/16	1 7/16	11/16	13/16	18
1/2	3/8	3/8	3/4	3/4	1 1/2	27/32	15/16	14
FOR ALL PRESSURES								

Fig. 1. Acceptable forms of fusible plugs according to the A.S.M.E. code

according to the A.S.M.E. Code and many manufacturers have failed to produce a good plug because they did not follow the dimensions as given in the tables. Other manufacturers have failed because they did not properly tin the hole in the bronze casing before casting in the filling of tin. We wish to quote the following paragraph from the Massachusetts code:

"All fusible plugs shall consist of a bronze casing, —holes in which shall be reamed and tinned before being filled, shall have an even taper from end to end not less than 5/8 in. to the foot, and shall be filled with 99 per cent pure tin."

The U. S. Marine Code says among other complete specifications that the inside of the casing must show that the tin filling was properly alloyed to the casing.

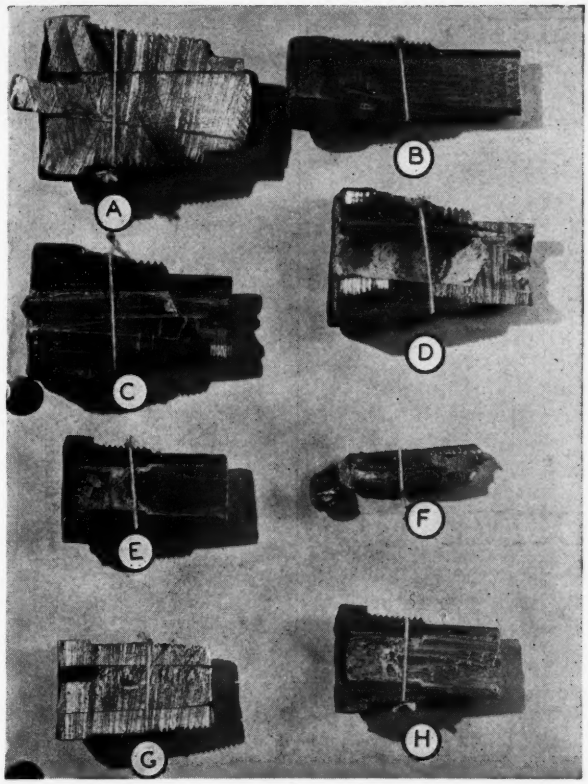


Fig. 2. Fusible plugs that have become defective in service

The writer has been saving used fusible plugs for some years to see what goes wrong with them. A representative lot of these are shown herewith—Fig. 2. These were cut in two with a hacksaw and mounted on a board to be photographed.

Figure 2A of this plate shows how a plug begins to deteriorate in use when the head of the plug sticks out too far into the flame pass. The exposed bronze head overheats like a soldering iron heats up and the tin filling begins to ooze out the end of the plug. Also on account of the tin expanding faster (See coefficients of expansion of bronze and tin in Kent's Handbook) than does the bronze casing, the filling begins to bulge out on the inside or water side. Next the filling core works loose from the casing and the water begins to seep out around the core leaving its sulphate of lime in the interstices behind it. Figures 2E and 2H show similar plugs a little later in their history when the tin has entirely disappeared from the fire end of the plug and has been replaced by infusible solid filling of sulphate of lime. In this condition the plug will not blow at all. It can thus be understood by the reader that the fuse plug too long in use generally deteriorates at the fire end.

In Fig. 2C and 2D, however, are shown plugs which lost their filling at the water end, and the water end for about an inch back was filled with hard infusible sulphate of lime scale and the plug has ceased to leak. When this plug in Fig. 2D was sawed in two, what was left of the tin core fell out and is shown in Fig. 2F. I might add that the cores in all the samples shown were found loose from the shell.

Figure 2B is a design of plug that is too long, it did not screw in more than three threads, so there was more of it sticking out into the flame than into the water; this kind rapidly deteriorates in use.

Figure 2G was an inside type fusible plug that was screwed into the shell from the outside by mistake and was found and removed by the inspector before it blowed prematurely. On sawing it in two we find the core is entirely loose from the shell. Also there are blow holes in the tin showing that the core was poured too cold. This condition leads us to believe that

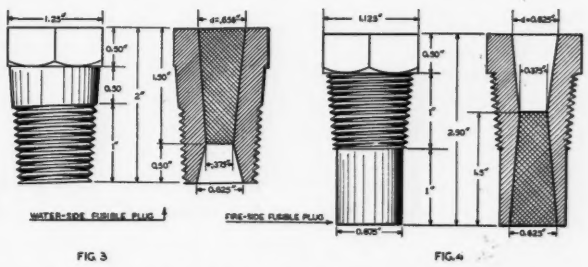


Fig. 3. Water-side fusible plug approved for marine service
Fig. 4. Fire-side fusible plug approved for marine service

in addition to being tinned, the bronze case ought to be preheated when pouring so that the case and the core will shrink in unison when cooling.

Also we wonder whether a metal or alloy might be discovered that would have the same coefficient of expansion as tin so there would be no tendency for it to work loose from the case.

I think the reader will agree that the following conditions are sufficient reason for condemning a plug that is in use and requiring that a new one be installed,—

A. Plugs of wrong type or defective design or that stick out into the flame pass too far.

B. Plugs that leak either around the thread or at the core.

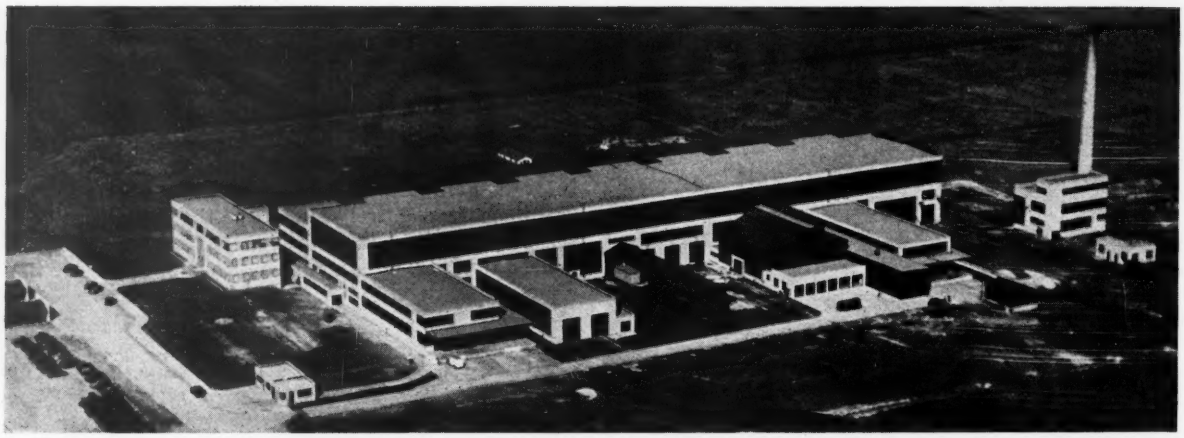
C. Plugs in which the core has slipped or bulged at either end.

D. Plugs in which the fire end shows the characteristics of tin oxide which melts at considerably higher temperature than metallic tin.

E. Plugs that have been in use for too long a time.

In Fig. 3 and 4 are shown the new design of fusible plugs for use in marine service and which we think are a step in the right direction in that the plugs are recessed at the fire side, thus the tin core is situated so that it is surrounded by water on all sides and will be kept cool at all times so that it will not deteriorate so fast. In criticism, however, of its use for land boilers we wish to point out that the threaded part of the plug is too long for most land boilers. The Scotch marine boiler often has a shell an inch or more thick, whereas a horizontal tubular boiler is rarely over ½ or ⅝ in. thick and the thread should be short enough so that the head of plug will bottom up against the shell of boiler.

If the new design of marine plug is as successful as we expect it to be, I believe the A.S.M.E. Code Design should be altered and recessed in the same manner.



Diesel Locomotive Factory *Goes Into Operation*

Electro-Motive Corp. Starts Production in First Exclusive Diesel Locomotive Factory Equipped with All Modern Facilities.

PRODUCTION of Diesel locomotives for American railroads is now underway at the new plant of the Electro-Motive Corp. at LaGrange, Ill. This is the first railroad equipment subsidiary of General Motors and the first plant in the world for the exclusive manufacture of Diesel locomotives. The plant started with work in process upon approximately $3,500,000 worth of equipment and with employment of 350 persons.

The Electro-Motive Corp., which became a subsidiary of General Motors in 1930, has been in railroad equipment construction field since it was organized in 1922 by H. L. Hamilton, president. Headquarters originally were in Cleveland, Ohio.

Construction of the new plant grew out of the development of a two-cycle Diesel engine by engineers of the Winton Engine Corp. and by engineers of General Motors Research Laboratories. With demand for the new power increasing, the Corporation realized it could not properly develop in the new field without its own plant, so in January, 1935 it was decided to build one.

Ground was turned on the 74 acre site approximately a mile south of LaGrange, Illinois, on March 27, 1935. Construction work was completed approximately seven months later. Tooling and smoothing out of production processes has proceeded since then.

The plant was built by The Austin Co., to facilitate the application of progressive production methods in the manufacture of locomotives weighing up to 200 t. and its giant welded electric traveling crane is the largest ever operated on a welded structure.

Electrically welded structural steel throughout nine buildings included in the project affords an unusual application of welding for heavy structural work. Much of the welding was done right at The Austin Co.'s structural shop in Cleveland, from which 104-ft. roof trusses and 65-ft. columns weighing 7 and 8 t. respectively, were shipped in prefabricated state to facilitate erection on the site.

Current Distribution

Size of the structure and the necessity for the diversified current distribution to all parts of the plant for purposes of illumination, welding and a wide range of machine operations resulted in the installation of individual transformers on alternate columns along the entire length of the main aisle on the west. In this way the necessity for installing three or four sub-stations through the building, each with its own oil cooled transformers, was avoided and small transformers were provided at 48-ft. intervals with three phase 440 v.

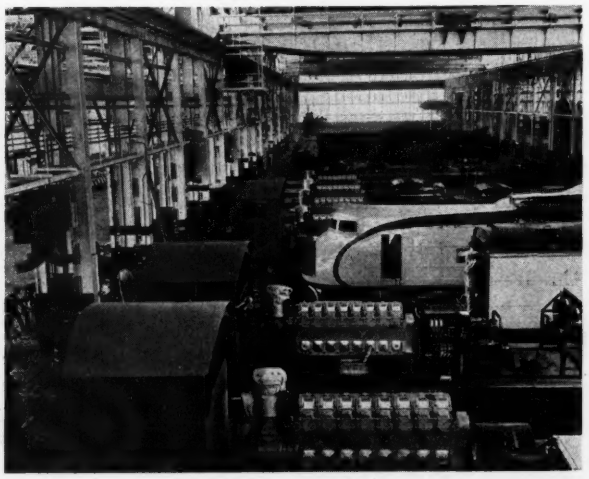


Fig. 1. General view in erecting shop

feeders carrying current to the lighting transformers which convert this power into a single phase 220 v., with 110 v. secondary.

Measured illumination has been provided throughout the plant by direct lighting. Aluminum reflectors with special non-corrosive finish assure undiminished brightness without excessive maintenance. These reflectors carry 1000 w. lamps on the roof trusses 49 ft. above the working floor in the main aisle. They are arranged so that the traveling cranes cannot interfere with the light from more than one outlet at one time.

Makes Own Power

At the north end of the main building is a testing room where two Winton Diesel engines will be on test at all times. Power generated by these engines is adequate to meet the direct current demands of the plant but a motor generator set has been installed for standby service. Because of the necessity for changing the engines on test at frequent intervals, this section has been fitted with a removable roof and can be served by the two cranes in the machine shop aisle. Adjacent to this engine test room is a locomotive testing pit and the power generated here can likewise be converted into constructive use in the plant.

With this source of industrial power and its own complete water supply system, modern sewage disposal plant, fire protection apparatus, and efficient heating plant, the works could operate entirely independent of all public service facilities. A 1600 ft. well, drilled through the limestone bed, furnishes water at a rate of 310 gal. per min. to the 200,000 gal. reservoir whose capacity would be sufficient to supply the needs of a community with 2500 inhabitants.

For the Future

The layout has been designed to accommodate shops four times the present size without augmenting the service facilities. It will permit extension of the plant to double its initial length without necessitating the installation of additional cranes, and duplication of such extended facilities on foundations partially in alongside the west wall of the present building. In this way, the 200-t. crane, the 40-t. crane and the 30-t. crane in the main erection aisle and the two 20-t. cranes in the machine shop, will be available for service over an area double that of the present structure.

A three story and basement office building of modern design serves as business office for the Electro-Motive Corp. and headquarters for its engineering staff, which has been provided with a drafting room occupying the entire upper floor. A complete Frigidaire air-conditioning system has been installed in the office building, with automatic controls to cool the air in summer and circulate and humidify warm air in winter.

Fig. 2. Two boilers served by underfeed stokers furnish steam for heating

Fig. 3. Forced draft fans under back of boilers with combustion control unit mounted on steel column

Boiler Plant

Steam, water, electric power, and air to the Diesel locomotive plant of the Electro-Motive Corporation are supplied from the boiler house. This power plant supplies steam for heating all manufacturing buildings, including the main office building, the employment office building, as well as steam for drop hammers and water heating.

Adjacent to boiler house is the pump room housing a deep well pump. supplying water to the entire plant. A fire pump, pumping from the adjoining reservoir to the underground fire protection system, and an emergency pump arranged to pump water from the reservoir to the service water lines in the event of a failure in the deep well pump, are likewise installed in this building.

Adjoining the pump house is the main switchboard room controlling the secondary services from the large outdoor substation which supplies a.c. power to the plant. Direct current power is regularly furnished from Diesel driven d.c. generators, located temporarily in the main manufacturing building.

A temporary engine room was built in the end of the machine shop to house these Diesel d.c. generators as well as air compressors. This equipment will be moved later as the plant develops to a new engine room to be built between the boiler house and the main erection shop. The boiler house at present houses two 332 hp. 3-drum water tube boilers, with space provided for an additional 500 hp. unit.

The present boiler house unit is a single-aisle building approximately 50 by 60 ft., with space left on the east for an addition to provide for a second row of boilers, when needed for future development of this plant. The present demand for steam is approximately 20,000 lb. per hr., with a future potential demand of

80,000 lb. per hr. and above. The boilers are set 12 ft. from the floor to the center of the rear drum, and are equipped with single retort underfeed stokers and motor driven forced draft fans. This setting is undercut in the rear and the forced draft fans are placed in this space directly to the rear of the boilers. The boilers have welded drums, and are equipped with Diamond Power Specialty Co.'s soot blowers.

Stokers are designed to operate the boilers at 200 per cent rating. Operating pressure is 100 lb. but the boilers are designed for 160 lb. pressure. The boilers are Babcock & Wilcox type "H" Stirling boilers, with filter baffles, and the stokers are Combustion Engineering Co.'s type "E" center retort underfeed stokers, with a furnace width of 7 ft. 11 in. and a length of 9 ft., having an effective grate surface of 71.25 sq. ft. for each stoker.

Fig. 4. Boiler control instruments, feed pumps and feedwater heater

This boiler plant is designed to operate at 150 per cent rating continuously, and 200 per cent rating for the peak loads, and is designed to burn Illinois and Indiana coals. Overall efficiency of boiler and stoker at the 150 per cent rating is 74½ per cent. Hagan regulators control the air supply, the stokers and the dampers. The forced draft fans are Buffalo Forge No. 4 S.L.D. double width, double inlet fans, and are direct connected to Delco ball bearing motors operating at 1760 r.p.m. Inlet vanes distribute the air into the fan wheel and each outlet is provided with a balanced type ball-bearing damper, which is controlled by the Hagan regulator. A Buffalo flexible coupling is provided for the motor connection to each fan.

Both the front and rear walls of boiler setting are of Bigelow-Liptak Co. unit suspended wall construction, with Silicon Carbide faced walls in the lower 12 in. of bridge wall at the clinker line. Side walls are 18 in. solid refractory walls, with 9 in. of No. 1 A.P. Green Co.'s Missouri fire brick for the furnace lining and first pass. Second and third passes are second-quality Missouri brick, and the balance of the settings are Illinois wire cut fire brick. High temperature cement was used throughout the furnace lining.

Republic steam flow meters are provided for each boiler connection, mounted on the boiler columns at the front of the boilers. Steam flow meters are equipped with temperature recorder, indicating the uptake temperature, as well as steam flow. Draft indicators are mounted directly over the steam flow meters. These draft indicators indicate wind box pressure and furnace draft. Water level is indicated by columns furnished by Reliance Gauge Column Co.

The chimney is radial brick, built by Alphonse Custodis, and is 175 ft. high, with an interior diameter at the top of 90 in. The chimney is constructed of buff brick and is provided with interior ladder, lightning rods and obstacle lights. In the concrete foundation of this chimney is provided a reservoir for the collection of sanitary sewage and the sewage ejector pumps are located in a room constructed in this foundation. These sewage ejector pumps discharge to the sewage disposal plant, located several thousand feet away.

Water Handling System

Two boiler feed pumps are 10 by 6 by 10 in. Worthington horizontal duplex piston pattern pumps, and are equipped with Hills-McCanna forced feed mechanical lubricators. The boiler feed pumps are equipped with excess pressure pump regulators and the boilers are provided with water line governors. The feedwater regulators and the pump governors are of Swartwout Co. manufacture.

Feedwater heaters and hot well consist of a Cochrane direct contact type open feedwater heater, mounted directly above a welded steel tank 4 ft. in diameter by 8 ft. long. This hot well and heater is mounted on a steel platform 8 ft. above the boiler room floor, and the boiler feed pumps are set directly underneath this platform.

A very small amount of make-up water is required as practically all condensate from the plant is pumped back to this heater and hot well. The pumps handling the condensate from the heating system are located in the factory building and office building, and discharge directly to the heater and hot well.

All piping throughout the boiler room is of welded construction, using Tube-Turn fittings at all turns. All hot piping is covered with magnesia covering of standard thickness, and the feedwater heater and hot well are covered with 1 in. magnesia blocks and cement finish.

Coal is received in cars and dumped into a 10 by 10 ft. track hopper with bar grating. This track hopper discharges to a reciprocating plate feeder, 24 in. wide, and the feeder in turn discharges to the vertical bucket elevator. Space is provided for the future installation of a coal crusher between the plate feeder and the vertical bucket elevator. The latter is of the centrifugal discharge type, with 12 by 7 in. buckets, spaced 18 in. on centers and discharges to a drag chain distributing

conveyor, delivering directly to the coal bunker, and the coal is spouted from the coal bunker to the stoker hoppers. Provision has been made so that if desired a traveling weigh larry may be installed at a later date.

Coal handling equipment has a capacity of 40-t. per hr. This equipment is motor driven, consisting of a 2-hp. motor drive on the reciprocating feeder. There is a 5-hp. motor on the bucket elevator, and a 5-hp. motor on the distributing conveyor. This equipment was manufactured by the Palmer-Bee Co., and the motors are Delco motors.

Directly to the east of the boiler house is the pump house which supplies water for general use throughout the plant. This building was erected after the drilling of a 1600 ft. well, and is directly over the well casing. This pump house contains a deep well pump and hydro-pneumatic tank, and also electric-driven fire pump.

Directly adjoining the pump house is a 200,000 gal. concrete storage reservoir for fire protection and cooling water for the compressors and Diesel engines. The electric-driven fire pump, emergency service water pump, and a large pump supply cooling water to the Diesel engines and air compressors are located in the pump house. The Peerless deep well pump has the bowls set about 380 ft. below the ground surface. It has a capacity of 300 gal. per min., and discharges to a hydro-pneumatic tank system. The pump is automatically controlled and arranged to cut out at 50 lb. pressure, and in at 35 lb. pressure. This pump is driven by a vertical U. S. hollow shaft motor, and the control equipment was manufactured by the Clark Controller Co.

Fire protection is provided by a 1000 gal. per min. Underwriter's centrifugal fire pump, discharging to the underground fire lines serving the sprinkler systems and hose hydrants. This pump was manufactured by the Worthington Pump & Machinery Corp., and is direct connected to a 75-hp., 1800 r.p.m. Pawling & Harnischfeger motor. The control for this motor is a combined manual and automatic across-the-line type, squirrel cage motor starter. This starter was furnished by the Clark Controller Co.

A by-pass connection is provided from the deep well pump to the reservoir. The fire pump takes its suction directly from the reservoir as does the pump supplying cooling water to the engine room; and also the emergency pump supplying water to the underground service lines. The emergency service pump has a capacity of 100-gal. per min., when discharged against the total head of 50 lb. pressure. The pump supplying water to the air compressors and Diesel engine cooling equipment has a capacity of 600 gal. per min.

Adjoining the pump house is the switchboard room, with a main switchboard connecting the 440-v. secondary feeders to the main manufacturing building. These feeders are run underground, using lead covered cables in fiber ducts. Power is brought into the property at 33,000 v., and stepped down to 2300 v. by the Public Service Co. of Northern Illinois, in an outdoor substation directly to the north of the switch house.

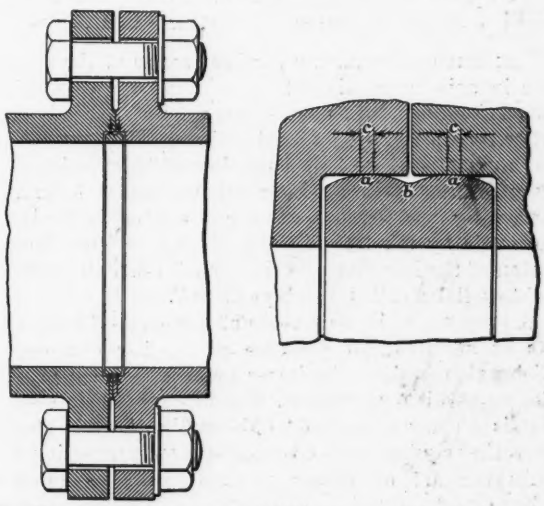
Power is furnished to the Electro-Motive Corp. at 2300 v. and metered on the 2300-v. buses. The utility company's meters are located in the switch house. An outdoor substation stepping down this 2300-v. power to 440-v. is provided just outside the switch house. A 2300-v. feeder runs from the primary buses to the main switchboard in the main power plant, where 2300-v. is used for a d.c. motor-generator set and for driving all air compressors.

Outdoor oil switches are provided connecting the 2300-v. service to the main manufacturing plant, and also to the 2300-480 v. transformers.

High Pressure Pipe Joint of Novel Design

DEVELOPED in the laboratories of the Imperial Chemical Industries, Ltd., of England, a new high pressure joint for steam or other fluids was described in a recent issue of "Engineering." In this type of joint, known as the wave-ring, the sealing pressure due to tension in the flange bolts, is replaced by a radial pressure due to the pressure of the fluid in the pipe. The construction is shown by the illustration.

As will be seen, the periphery of the ring has two swellings, or waves (a), on either side of the trough (b). The maximum diameter of the ring is made slightly greater than the internal diameter of the socket so that interference fit is obtained at the crest



The Wave-Ring, a new type of high pressure joint developed in England

of the waves (a) as indicated by (c). As the internal surface of the ring is exposed to pressure, it tends to expand and the proportion of the parts are chosen so that the external diameter of the ring increases by a greater amount than the internal diameter of the socket so that an increased sealing is effected.

The process of making the joint is simple. The ring is first forced into one of the sockets, the second flange placed in position and the joint drawn up by means of flange bolts which can then be slackened off and tightened only by hand so that there will be no initial load on the joint. Different materials can be used depending upon the service and apparently the joint may be opened and remade a considerable number of times without refacing. One joint in service under a pressure of 10,000 lb. per sq. in. was opened 400 times without refinishing work being done on it.

Midwest Engineering Power Conference

Abstracts of several papers presented during the Conference held in Chicago

DURING the week of April 20, as a coöperative enterprise, seven important engineering societies conducted a meeting at which many phases of mechanical power were discussed by men of national reputation. As indicated in the full program printed in the April issue, sessions were arranged for the presentation of papers dealing with social and economic as well as the technical aspects of power problems, and a report of the conference will be given in the June issue of Power Plant Engineering. In the following paragraphs, however, are abstracts of several papers, secured in advance of their presentation, which are of special interest to power plant engineers.

Superposition

By Frank S. Clark, Consulting Engineer
Stone & Webster Engineering Corp.

The idea of increasing the heat range of the steam cycle in existing stations to obtain greater capacities and efficiencies is not new. Pressure limitation in the earlier days confined its application to the lower end of the cycle, and we had a number of installations of low pressure turbines taking exhaust steam from reciprocating engines. The most noteworthy example is that made by the late H. G. Stott in the 59th Street Station of the Interboro Rapid Transit Co. This method might well be called "Sub-position".

Superposition is the reverse of this method and consists of adding high pressure generating equipment which exhausts into the lower pressure system of the existing turbine generators. Steam condensing equipment is a concomitant of "Sub-position" while steam generating equipment is a requisite of "Superposition".

As the art of power production has advanced, higher pressures and temperatures have come into use with correspondingly better efficiencies. With the advent of pressures of 650 lb. and 1250 lb., superposition became an attractive proposition. The 1200 lb. installations at Edgar, Gilbert, and Deepwater, and those of 600 lb. at Philo, Twin Branch, Crawford Avenue, and Columbia were in reality superposed units. The same principle was just as applicable to existing low pressure plants, but was retarded by the necessity of using the reheat cycle.

The advent of 850 deg. F. and of 925 deg. F. steam temperatures permitted the use of the straight regenerative cycle, and gave impetus to superposition of equipment on present stations. A considerable portion of the generating capacity in these stations operates at pressures of 300 lb. or less, and with heat consumptions of 18,000 B.t.u. per kw-hr. or greater. It is to these stations that the principle of superposition is particularly applicable.

The subject is so varied in its scope and application that it can be treated here only in a broad way. It is not, however, the obvious answer to every problem, but must be studied carefully for each case and in the light of other methods available. Chief among these are:

1. Improving efficiencies by minor changes in existing equipment or heat balance.
2. Increasing capacities of existing steam generating equipment by improved methods of combustion and by modernization of turbine generators.
3. Additions to existing stations either at present operating pressures or at increased pressures.

The first two of these alternates may properly be classed as "Rehabilitation" and in cases where improvements in efficiency are the main objective, or where a relatively small capacity increase will suffice, their adoption may well be justified. Also, in the case of the third alternate an extension to an existing station rather than superposition may be shown to be the proper procedure. Whether this be made at the same or at a greater pressure than that in the plant will depend on its age. The adoption of such a course does not shut the door on superposition at some future time.

In general, the stations to which superposition will be found adaptable vary in age from 10 to 25 yr. Possible capacity increases up to 50 per cent may be obtained and efficiencies bettered by as much as 40 per cent. Offsetting this betterment to a greater or less degree is the fact that it is obtained at the expense of other stations in the system which must operate for a time, at least, at lower load factor and less efficiency. It is necessary to study its effect on the whole system to determine the economies of superposition.

Superposition is attractive in stations where installed turbine capacity is in excess of boiler capacity. This excess capacity is available for superposition without sacrifice of steam generating facilities.

Superposition permits additions of capacity in smaller increments that more nearly fit growth than is the case where these are made in relation to total system load, and the capacity of the largest installed unit. It has great possibilities in cases where condensing water is limited and also where present sites are wholly utilized. It takes advantage of existing plant facilities and increases the utilization of established transmission and distribution facilities.

Application and cost of superposition will vary with each proposition. The high degree of reliability of steam generating equipment may dictate the installation of a single boiler per turbine. Structural limitations of existing buildings, percentage of capacity superposed, or load conditions, however, may require the use of two or more boilers each of smaller capacity. The obtaining of a satisfactory heat balance may impose certain restrictions and arrangements not otherwise necessary.

The mercury vapor turbine fits naturally into the scheme of superposition. Four installations have already been made and with further development and commercialization further use of this method is to be looked for.

The Steam Turbine, Its Place in the Industrial Power Plant

By J. M. Lenone, Wilson & Co.

The best way that I could think of to tell about the steam turbine and its application in the industrial field, is to describe the conditions at the Wilson & Co. plant in Chicago, and the way we solved the problem of reducing the cost of power.

This plant was buying electric current for power and light at the rate of 1,500,000 kw-hr. per month with a demand rate of 3200 kw. The monthly bills for this energy averaged $10,500. At the same time we were producing steam to drive compressors and pumps, to process food products and to heat products, water and buildings.

The decision to replace the old boilers gave the engineering department the opportunity to plan for the generation of our own electric current. The engine and turbine drives on the various units were in good condition and designed to operate on 150 lb. steam pressure. The food processing equipment required steam at 70 to 80 lb. pressure in order to give the proper temperature. The heating steam was being used at 3 to 5 lb. pressure, most of it being the exhaust from non-condensing engines and turbines. The steam demand for a normal full production day was 183,500 lb. per hr. 87,500 lb. through power engines and then to low pressure heating and 96,000 lb. for processing.

Because the existing plant operating conditions could not be changed and, to get the best operating economy, we must not generate more steam than required for process and heating, it was evident that the electric generating plant would have to be superimposed on the present plant or, as we are learning to say, a "Top" plant.

The new operating conditions were found by taking the total heat in the 183,500 lb. of steam per hour at the various pressures needed for plant use and to this adding enough heat to generate 3500 kw. per hour. The result was a total heat of 1277 B.t.u. per pound. The superheat must be just enough to assure dry steam at the turbine exhaust and not so much as to cause lubrication and packing trouble in the steam bled from turbine for use in the engine cylinders. The choice that gave the desired water rate for the turbine and, at the same time, met these conditions was 395 lb. absolute pressure and 550 deg. F. total temperature or 107 deg. superheat, and this was the condition fixed for the steam at the boiler outlet. We installed three boilers, each with a normal capacity of 130,000 lb. of steam per hour, pulverized coal fired, with economizers and air-preheaters and we are getting an overall efficiency of 87 per cent in their operation.

We installed three turbine generators, one of 3125 kv-a., one of 2500 kv-a., and one of 1875 kv-a. capacity which, at the existing plant power factor of 0.80, would deliver 2500, 2000, 1500 kw. respectively. The reason for this selection of sizes was that we could operate one of the machines to carry the small load at night and on Sundays and holidays and, with two machines going, could carry a day load of from 3500 to 4500 kw. By selecting synchronous motors with 80 per cent leading power factor for driving the fans and pumps in the boiler house, we have raised the plant power factor to 0.91 which increased the kilowatt capacity of the generators in proportion.

The conditions of operations in the plant, with a normal production load, are as follows:

The boilers deliver steam at 380 lb. 550 deg. F. to the turbines at the rate of 183,500 lb. per hr. 87,500 lb. per hr. is extracted at 155 lb. pressure and goes to the engine driven ammonia and air compressors and to the engine and turbine driven pumps, 90 per cent of these operate non-condensing and 70,000 lb. of exhaust at 10 lb. is used to heat water, product and buildings. To supply the processing steam requirements of the plant, 90,000 lb. per hr. is drawn from turbine at 85 lb. pressure. The remaining 6000 lb. per hr. of steam exhausts from the turbine at 10 lb. pressure, and with the 70,000 lb. per hr. engine exhaust, supplies the demand for heating steam.

The extraction of steam from the turbines is under full automatic control by means of inter-stage grid valves in the turbine which act to maintain a fixed steam pressure in the extraction lines up to the limit of the turbine capacity. Variation in the electric load and in the amount of steam extracted call for changes in the amount of steam entering the turbine and this is also controlled automatically by a group of nozzles discharging from the high pressure steam chest and which open and close in sequence under control of the first stage pressure governor. The speed control is an oil pressure system so that an increase of turbine speed increases the oil pressure and trips the closing mechanism on the main throttle valve. Additional safeguard is provided by an electric trip, actuated by over speed of the electric generator, to operate the main throttle valve closing mechanism.

Duplicate equipment of pumps that can be either steam turbine or motor driven and a 900-hp. engine that can operate either condensing or non-condensing are used to make the necessary adjustments to balance the electric load with the steam demand.

Economies realized in cost of power were most gratifying. The new plant, including boilers and turbines, cost $700,000. Our old boiler plant produced steam at 150 lb. pressure, saturated, from feedwater at 200 deg. F. with an overall efficiency of 67 per cent, and 183,500 lb. steam was produced from 12.35 t. coal. The new boilers generate steam at 380 lb. pressure, 550 deg. F. temperature from feedwater at 230 deg. F., with an overall efficiency of 87 per cent and 183,500 lb. steam is produced from 10.00 t. coal, which is a saving of 2.35 t. per hour. In addition, we saved the money paid for electric current, some $126,000 a year. We are able to burn the coal marketed as carbon and costing much less than the stoker coal we used before. Altogether these items show a saving of $163,430 for last year's power cost over that of a year's operations before the improvements were made.

Design and Construction of Valves For High Pressure Power Plant Piping

By H. H. MacMillen, Milwaukee Elec. Ry. & Lt. Co.

One of the latest high pressure steam power plants is the Port Washington station of The Milwaukee Electric Railway and Light Co., which was placed in operation on November 22, 1935. A descrip-

tion of the operation and construction of some of the principal high pressure and special valves in this plant, together with some details on the construction of fittings and piping, will be of interest to users and builders of valves and fabricators of fittings and piping.

The plant is a unit installation, consisting of one boiler and one turbine, the turbine being an 80,000 kw. unit, designed for a steam pressure of 1230 lb. ga. per sq. in., 825 deg. F. The boiler is of the three drum, bent tube design, with radiant superheaters in the side walls of the furnace and convection superheaters between the first two banks of the boiler. Steam, after passing through the high pressure section of the turbine, is returned to a radiant superheater located in the rear wall of the furnace, where it is reheated from 612 deg. F. to its original temperature of 830 deg. F. and then returned to the turbine. The steam pressure of this reheating system is 425 lb. ga. at full load. Branch steam lines with special desuperheating valves in them, allow steam to be passed through the reheater for cooling purposes when turbine is not operating. Specially designed intercepting valves located in the reheater lines near the turbine, control the flow of steam between the turbine and reheater.

Feedwater heating is accomplished by means of a special construction of high pressure extraction heaters placed in the discharge lines between the boiler feed pumps and the boiler.

The high pressure steam gate valves and fittings for this installation are designed for the various pressures and temperatures required, the maximum being 1350 lb. ga. steam pressure, 850 deg. F. total temperature. The maximum pressure in feedwater lines is 1800 lb. ga. pressure, temperature 450 deg. F. All gate valves are designed to open and close under a full flow of steam or water. Bonnet equalizing lines connected into the regular by-pass pipes are provided to balance the pressures on the top and bottom of the gates when they are being moved off their seats. The bodies and bonnets of these valves are of chrome molybdenum steel castings, with gates of the wedge type of chrome molybdenum steel, having stellited faces. Valve trimmings are of stainless steel or iron. Special valves of the globe pattern for high pressures and temperatures for the desuperheating of steam, automatic intercepting valves in steam lines between turbine and reheater, feedwater control valves, stop and check valves, and others, have similar materials of construction in their various parts as the gate valves. Each valve, however, is designed with special features so that it can function properly for the service desired and under varying conditions of pressures and loads.

Studs used for temperatures above 750 deg. F. are chrome tungsten Bethlehem Supertemp, while those for temperatures below 750 deg. F. are chrome nickel steel. All studs for high temperature service were calipered before and after pulling up, to insure even stresses in joints on all high temperature lines.

The design of this station was made by The Milwaukee Electric Railway and Light Company's own engineers, and the work was erected by their mechanical force. The design and selection of the valves and other piping materials, therefore, represents the personal conclusions of The Milwaukee Electric Railway and Light Co. engineers of the requirements for the operating conditions peculiar to this station.

Water Conditioning for High Pressure Steam Generation

By R. E. Hall, Director, Hall Laboratories, Inc., Pittsburgh, Pa.

The purpose of the paper is to answer the question—"Has Development in Water Conditioning Kept Pace With the Other Advancements in Steam Generating Work?"

The answers are developed under the quartet of division usual in discussions of water conditioning work—Prevention of Scale, Carry-Over. Corrosion, and Metal Cracking.

The topics discussed under Corrosion are—

(1) The change of hydrogen ion concentration or acidity of pure water with temperature. "Thus, neutral water, on the basis of measurements taken at 557 lb. pressure, has a hydrogen ion concentration which corresponds to pH value of 5.6. This increase in the hydrogen ion concentration of water has the significance in water conditioning work that the alkalinity of the boiler water must be maintained with the greatest certainty at all times in order to repress fully any activity of the hydrogen ion at these higher temperatures or pressures."

(2) Corrosion of the metal by direct union with steam.

(3) "With the water held constantly alkaline, to what extent should dissolved oxygen be removed? The answer is quite definite—it should be completely removed." Heaters and deaerators are in the primary line of defense, followed by a chemical line of defense.

(4) What is the meaning of the copper deposits which are so frequently found in boilers, and what is their effect on the boiler?

The discussion of Carry-Over takes for granted ordinary care in providing correct water conditions, describes simple methods of providing protection to the steam in some of the older types of boilers, and finally, takes up the question of conditions under which the droplet of water is borne along by the steam, without possibility of its dropping out of itself, and the value of washing the outgoing steam with feedwater under these conditions is emphasized.

Under Prevention of Scale Formation, emphasis is placed upon a number of factors—

(1) Disappearance of various boiler water constituents at high rating, and their reappearance at low rating, signifying surfaces in the boiler on which extreme concentration is occurring at high rating.

(2) The relation of the solubility curve of various constituents found in the boiler water to this phenomenon.

(3) The relation of these solubility curves to the deposits which develop in high-rating and high-pressure boilers.

(4) The relation of these curves to the deposits in the superheaters.

(5) The relation of these solubilities and the composition of the steam to the turbine deposit.

The subject of Boiler Cracking is touched on but briefly. The relationship of silica thereto is discussed briefly.

Readers' Conference

Laying-Up Boiler

I ENJOYED READING your article, "Laying-Up Boilers" on page 160 of the March issue of Power Plant Engineering.

My files contain the following clipping taken from "World Trade Notes on Chemicals and Allied Products"—July 24, 1933:

"AMMONIA FOR PROTECTION OF IDLE STEAM BOILERS. Steam boilers which must remain idle for considerable time may be protected from rust by being filled with gaseous ammonia, according to experience of the Merseburg ammonia works of the I. G. Farbenindustrie. The boiler is dried as well as possible, filled with ammonia gas from as steel cylinder, and closed hermetically. Ammonia reacts with the remaining moisture to form compounds which act as rustproofing agents. The dry parts are, of course, sufficiently protected. When it is desired to use the boiler again, the gas is driven off by filling the boiler with water, the excess water is removed and the boiler is ready for firing. (Consul General W. L. Lowrie, Frankfort-on-Main.)"

This particular treatment would likely be impractical on low pressure boilers on account of brass fittings which would be corroded by damp ammonia. This method of rust prevention offers interesting possibilities in all-steel equipment.

Philadelphia, Pa. L. H. BRANDT.

Power Plant Lighting

THE ARTICLE "Lighting Savings in Power Plants" by S. H. Coleman closely approximates one published in Power Plant Engineering in June 1935. Mr. Coleman is quite right when he says that it is small economies in this regard that add up to a sizeable saving over a period. When a plant is constructed it is almost impossible to figure up how many, where and what size lamps will be needed. All the designer can do is to let previous experience guide him and, as an additional safeguard, put plenty of outlets where he is in doubt.

It should be the direct concern of the operating force to cut down on unnecessary lights after they have taken over the plant for regular operation. If the operators will pull together they can eliminate those lights which are found not to be required. It is best to plug up the sockets. The method we use is to cut a small cardboard or tin disk which will fit inside the reflector and cover the socket. This is quite unnoticeable and prevents the lamp from being screwed into the socket. Quite often it will be found that a lesser wattage lamp will give good results. Install these wherever possible. Make it a rule that each man clean the reflectors in his section at regular intervals. See that he is also instructed to switch off lights when not required. Check up closely on replacements. If these become excessive the voltage may be wrong or there may be some small pilfering.

It is an excellent plan to make the men bring the old lamps back when drawing new as, by this simple means, a good check can be kept. It should be, and usually is, a matter of pride with the operators to keep expenses of all sorts down and, if they understand how unnecessary lamps add to power cost and renewals to maintenance cost, they will be careful to switch out those they do not need as soon as possible.

Rutherford, N. J. MARK BELL.

Flexible Shaft Construction And Maintenance

MOST OF US know something of the many modern applications of the flexible shaft in powering various types of mechanisms, and realize that it is one of the most convenient things imaginable for transmitting power around a corner or in an indirect route. Not so many of us, perhaps, know how the flexible shaft is constructed. It is made of wire, there being a core wire for a beginning. Around this core wire is wrapped a second wire in spiral fashion. Then, starting at the other end, a third wire is wrapped around the second, the spirals of the third being in an opposite direction to and crossing those of the second. Finally, a fourth wire is spiralled around the assembly, in the same direction as the spiral on the second.

In manufacture, these shafts are wrapped in very long lengths, and are cut off to form the shafts needed. In cutting them off, the process is such that great pressure is placed upon the wires at the end or point of cutting, forcing them together until they become almost one solid mass. In other cases, the ends of the shafts being cut are brazed together. This prevents the wires of which they are built, from unwinding.

Where a flexible shaft breaks and must be repaired, it cannot be done unless one of special type is bought, made in such manner that it cannot unwind. Such have lately been developed, and it would seem that they would have a wide application in places where severe service and heavy maintenance costs would make replacement with a new shaft in each case very costly. This will be especially true in those where shafts of considerable length are being used. In general, it is best not to have a flexible shaft longer than necessary for the service it is to render, but it is interesting to know that they can be successfully run when they are 20 to 30 ft. long, if and when necessary.

Peoria, Ill. JOHN E. HYLER.

Fixing the Simplex

FOR MANY YEARS it has been my experience that the one thing dreaded by engineers operating condensing engines served by simplex air pumps is the liability of pump failure when the engine is coming to rest.

Regardless of whether the engine is of the horizontal or vertical type, the piston (when steam is shut off) acts as a vacuum generating agent and tends to attract the flow of water toward the engine cylinder, especially if the air pump stops.

The vacuum breaker being placed on the condenser and actuated by a float does not (as proven many a time) save the engine from a dash of water.

The safest method to employ is a hand operated vacuum breaker as close to the cylinder of the engine as possible and when stopping the engine, break the vacuum at this point.

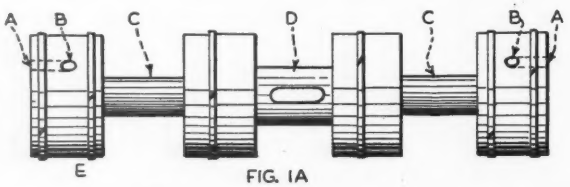


FIG. 1A

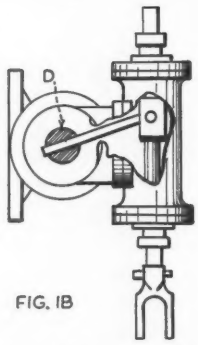


FIG. 1B

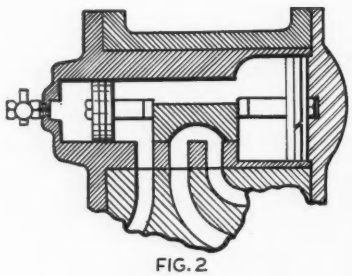


FIG. 2

Fig. 1. Multiple Piston Valve of Vertical Twin Cylinder Air Pump

A-B, Connecting Steam Ports

D, Slotted valve spindle, fitted with tongue to turn piston assembly, admitting steam through port B to A to move pistons and slide valves.

E, Piston, with ports, A and B. Inside pistons have no ports but have snap rings. Live steam is admitted between pistons, at C, to work main pump pistons. Steam and exhaust ports are provided to supply and release steam.

The upper sketch shows the assembly of four pistons which are actuated by steam at either end. As pilot motion turns the assembly through the tongue and slotted center, the ports B in the pistons, align with ports in the casing. Steam is admitted on one end and exhausted on other end, forcing the whole assembly to the other end.

If small exhaust ports are not of sufficient area to handle any leakage that may seep past the rings in pistons E, the assembly will become more or less balanced and refuse to work.

If a cock is tapped in the head (making two cocks for this type of pump) of the chamber carrying this valve assembly, a very smoothly operating machine may be the result.

Fig. 2. The locomotive air compressor pilot valve assembly: A, small piston; B, large piston; C, steam space

The pilot valve admits steam at the head end of the big piston. Pressure being equal, now, on both sides of big piston and on steam side of small piston, the valve is forced toward the left.

If the small piston leaks to such an extent that pressure accumulates on the head end, the whole apparatus will be balanced and the valve will remain in mid stroke, or, at right side.

By tapping the cock (as shown) in to the small piston cylinder head, this excess pressure can be relieved and the compressor will quite readily respond.

It is often possible to close this cock completely after the cylinder is properly heated and condensation nearly stopped.

When the pilot valve reverses, steam is exhausted from the head end side of large piston and due to the difference in areas of the large and small pistons the main valve is forced to right.

By extensive experimenting I have found that the stoppage of simplex pumps may be remedied and often cured by a simple method.

First, the reason of the stoppage must be known and nine times out of ten the answer is: more leakage than the auxiliary exhaust port can handle.

By this I mean that the pilot action is retarded by leakage so that auxiliary piston cannot reverse and change main valve.

The remedy is to tap cocks in the cylinder heads of auxiliary piston to relieve this pressure which is balancing the cycle and preventing action of the valve-gear.

Sketches will show the idea. The apparatus which has failed to function will take a new interest in mechanics and surprise the operator.

New York, N. Y. C. W. PETERS.

More About Gage Glasses

W. E. WARNER, writing from England, raises several very pertinent points about gage glasses and their correct installation. Whereas, if it is the common type of gage glass that is used, the replacement cost is not excessive but the new high pressures have brought into more general use the square glass, of several well known makes, the renewal of which runs into real money. These newer glasses are usually backed with thin strips of mica between the glass and the steam and water. As there are two glasses to replace together with double the number of gaskets, etc., it is not advisable to replace these more often than necessary.

Over quite a long experience I have found that several elementary precautions will prolong the life of gage glasses of all sorts.

I used to know an old engineer who immersed his new glasses in a pan of cold water; brought it to a boil slowly; kept it boiling for half an hour and then allowed the water to cool off. He used to swear that it toughened the glasses considerably and made them almost unbreakable.

I pass this information on for what it is worth.

Mr. Warner is absolutely right in all the safeguards and precautions he advocates. May I add another, rather elementary, rule? I have seen it omitted very often or I would not mention it. When taking the level by blowing down, always blow the column first, and then the glass. If, as often happens, the glass is blown and the column neglected, the glass, heated by the passage of the steam, is refilled with comparatively cold water from the column and is, thereby, subjected to excessive strain. If, as is the right method, the column is blown first, the column is refilled with water from the drum and then, when the glass is blown, the replenishment is of a much hotter temperature and more nearly approximates that of the steam.

As a matter of personal principle I am strongly against too frequent blowing of the glass and column, as it does, even when carefully done, shorten the life of the glass. Just so long as one is sure that the gage is correct, easily seen by fluctuations of level on load changes, etc., I feel that too frequent blowing is to be deprecated.

While on the subject, I am strongly against any and all of the various types of high and low alarms now being installed. It speaks worlds for the gullibility of owners that they fall for this kind of device. It should be the boiler operator's instinctive duty to

cast regular glances at his gage glasses and I have found, over many years' experience, that the installation of alarms makes them careless in this regard. Any trained engineer, even when not connected with the plant and possibly just passing through the boiler room, instinctively glances up at the gages.

Some time ago I went into the boiler room about 6:15 a.m. Looking up at the glasses I saw that the lamps behind them were out and the levels could not be seen at all. It was summer time and I asked the boiler operator at what time he had switched off the boiler room lights. He said—5:00 a.m. He had, obviously, pulled the gage glass switch in error at this time and had not noticed the mistake until 6:15 viz. 75 min. later.

This man is the proud possessor of a state license certifying that he is a competent boiler operator and engineer.

His action, to my mind, displays a touching faith in the automatic alarms or a crass ignorance, but either may, any day, land him prematurely at the Pearly Gates.

Rutherford, N. J. MARK BELL.

Combustion Control

ON PAGE 36 of the January issue, it is said that certain developments has "resulted in feedwater regulators becoming substantially part of the combustion apparatus in that they are often made responsive to the steam flow as well as to the water level."

We believe this statement tends to be misleading. There is a relation between feedwater regulation and combustion control, but there is no logical direct connection between them and they are not in any sense of the word tied together. Combustion control requires one type of treatment. Feedwater control requires another. The two controls should, for best interests, be separate.

Efficient operation of modern boilers depends almost entirely on the correct control of the three main factors entering into steam generation—fuel, air and water. Of the three, water is the most vital. An incorrect fuel-air ratio would obviously lower efficiency, but a failure of combustion control would not necessarily shut down the plant. An interruption of feed water in a modern high-pressure unit could be a very serious matter because of the small amount of time available to correct the condition. In modern boilers, there is comparatively little water in proportion to the amount of steam produced.

To attempt to make the feedwater control system a part of, or dependent on, the combustion control system is to introduce unnecessary complications. Improper operation, or failure, of the one would affect the other. Each is important enough to be considered an independent system and, in our opinion, best engineering practice demands this.

Apparently you base this inference on the fact that certain types of feedwater regulators are responsive to the steam flow. We cannot see that this changes the actual condition one iota. We first installed regulators of the steam-flow type some 8 yr. ago and have made successful installations of this type in something more than 25 different plants. In none of them has our experience led us to believe that any advantage could be gained by making the feedwater control a part of the combustion control system.

In fact, all indications are that, as stated above, good engineering practice will continue to keep these two important control systems in the modern boiler plant entirely separate and distinct from each other.

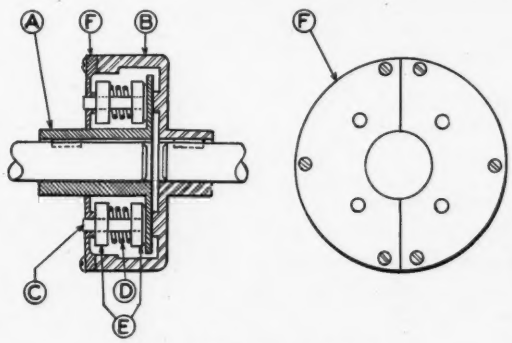
DON ALLSHOUSE.

Northern Equipment Co.,
Erie, Pa.

Friction Coupling

AN ARTICLE in the Readers' Conference of February issue of Power Plant Engineering entitled "Coupling for Small Drives" by John A. Honegger, brings to my mind a similar coupling which I developed several years ago.

In our control equipment we use fractional horsepower motors to drive light mechanisms which can easily be wrecked in case of a fault before the motor goes out on over-load. The manufacturer of this equipment supplied pieces of pure gum rubber to serve as couplings but due to oil which gradually attacked the rubber they had a short life of from two to three months. Hose with more fabric was tried with greater success but due to stiffness it was necessary to remove the motor each time a new hose was installed and also to wire each end of the hose tight to the shafts. This



Fractional Horsepower Coupling

latter fact at times restrained the motor from finding its electrical center and would cause the motor to run hot.

To cut down maintenance and interrupted service, I put in these friction couplings which have given excellent service and protection to the equipment. I have had seven couplings of this type installed for over two years. A description of the coupling follows:

The coupling as sketched consists of two major parts A and B keyed to the driven and motor shafts respectively. Part A is also held from moving horizontally by means of a set-screw which is not shown. A feather key arrangement for the motor shaft allows the motor rotor to shift properly in starting. The amount of torque developed by A is determined by the pressure of the friction shoes C against the disk part of A and the raised annular section of B. The friction shoe assembly consists of shoe and stem C, spring D and spring retainers E. You will note the shoe bearing plate F is split, each half being held integral with

part B by means of three screws. This feature facilitates inspection of internal parts without removing coupling from the equipment to which it is installed. Front view of F is rotated 45 deg. from the side view position. Combinations of 2, 3, 4 and 6 shoes can be used if desired by properly drilling the bearing plate F so that the shoes are spaced equidistant about the coupling.

Kenmore, N. Y. JOHN C. DOWNING.

Cleaning Conveyor Belts

WHEN MAKING repairs to conveyor belts such as making new joints, mending tears, etc., cleanliness is important especially between the plies. For removing dust and grit from inaccessible parts cleaning by a vacuum cleaner is the most efficient. This will remove any dust between the plies, so that a better repair can be made.

For cleaning any inaccessible parts of a conveyor a blast of high pressure superheated steam will be found efficient. Steam will be found much better than compressed air owing to its greater weight and force, and the heat softening any hardened oil so that it is carried away by the steam. The steam being at a high temperature quickly dries due to its own heat, so there will be no trouble due to accumulated moisture unless the jet is played too long.

Kent, England. W. E. WARNER.

Boiler Ratings

AT THE PRESENT time it is more customary to speak of boiler capacity in terms of pounds of steam generated per hour than horsepower as was done formerly. There is no doubt but that at the time the expression boiler horsepower was adopted it was fully adequate for the conditions then prevailing. An engine horsepower was the power exerted by a good horse, as determined by actual test, and the steam consumption of a good engine at that time was estimated to be 34.5 lb. per hr. which could be generated by every 10 sq. ft. of the heating surface of a boiler in good condition. So long as steaming rates of boilers remained around 3½ lb. per hr. per sq. ft., the expression boiler horsepower was just as much a practical unit of measurement as is the kilowatt in connection with the turbine. When the evaporation of some boilers runs as high as ten times what is considered normal, the usage of boiler horsepower becomes meaningless.

There is really nothing wrong with the term boiler horsepower. What is wrong is that it is hitched up with so many square feet of heating surface. Both engine horsepower and boiler horsepower have the same origin, yet engine horsepower has remained in use with no critic to challenge its right to live, while there has been considerable agitation against boiler horsepower. Had engine horsepower been defined in terms of some certain size piston or some other relation which could not endure as the art progressed, it too would have found its dishonorable grave.

In order to get a better understanding of what is really wrong with boiler horsepower as a unit of measurement we will compare it with the kilowatt as a unit of measurement for the turbine. Suppose that the value of the kilowatt, besides being defined as 3415 B.t.u. per hr., had also been expressed as a function of the diameter of the turbine wheel. So long as turbines remained of the original simple construction, the relation between the wheel diameter and the figure 3415 would have been in more or less harmony. Under such conditions, the kilowatt as a function of the wheel diameter, would serve as a very valuable means of judging merit. But as turbines changed from single stage into multi stage; as pressure, temperature and vacuum increased; as bleeding and other developments came into use, the relation between the capacity of the turbine and its wheel diameter would become meaningless.

Likewise the water walls, economizers, preheaters, fans, etc., have made the boiler horsepower of the 10 sq. ft. heating surface a thing of the past.

Some of the advocates of other units of measurement have suggested the use of plain square feet of heating surface. A little reflection should convince anyone that these engineers, though they know that there is something wrong with the term boiler horsepower, they do not know what really is wrong with it. It is wrong because it is defined as 10 sq. ft. of heating surface and the heating surface of a boiler does not give us any indication of its capacity.

Others suggest the use of kilowatt as the unit of measurement. But what is to be gained by its adoption? Is the boiler kilowatt to be hitched to 10 sq. ft. of heating surface the same as the boiler horsepower is? Of course not. Then what we need is not to call a boiler horsepower a boiler kilowatt but to divorce the boiler horsepower from 10 sq. ft. The use of boiler kilowatt in place of boiler horsepower is the same as calling a gallon a kilowatt and measuring oil by the kilowatt. Which can be done perfectly well but there is no sense to it.

If engineers will simply define a boiler horsepower as 34.5 lb. per hr. and forget all about 10 sq. ft. they need not worry about what other unit to adopt. It might be asked why should we divide a number by 34.5 and call it a boiler horsepower. For the same reason that we call 3415 B.t.u. a kw-hr. and so many square feet an acre. All units are interchangeable but men prefer to have a different unit of measurement for different quantities. The term boiler horsepower is on every page throughout the entire literature of steam engineering and is inseparable from its history. Boilers now are being spoken as 345,000-lb. unit, 100,000-lb. unit, etc., but they could with greater advantage be spoken as 10,000 b.hp, 3,000 b.hp., etc. All that we need to do is to stop associating boiler horsepower with 10-sq. ft. and define it only in terms of so many B.t.u., the same as the kilowatt is defined.

Chicago, Ill. N. T. PEF.

PURE WATER IS A very poor conductor. However, when a small percentage of hydrochloric acid (HCl) for example is dropped into it, the resulting solution becomes conducting in proportion to the concentration of acid in it, because water possesses the remarkable property of splitting HCl molecules into H and Cl ions, the H ion being positively and the Cl ion negatively charged.

New Equipment

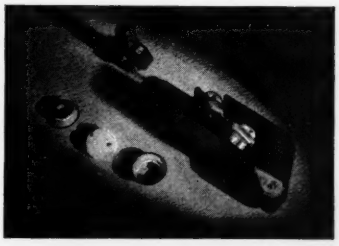
Leak Detector

LEAKS OF non-combustible halide gases when as refrigerants may be detected by a device known as the Prest-O-Lite Halide Leak Detector, developed by The Linde Air Products Co., 30 East 42nd Street, New York City. The detector consists of a regular Prest-O-Lite needle valve torch handle assembly, a burner which includes a suction nipple for attaching a rubber hose, and a chimney with a copper reaction plate. The rapid flow of acetylene through the burner causes a suction which draws in any refrigerant gas near the open end of the suction tube. The two-color variation of flame gives visible indication of the amount of refrigerant gas present. If there is a considerable amount of refrigerant gas in the surrounding atmosphere, the leak can be located by the variation in the intensity of the color of the flame.

Silent Switch

A SMALL COMPACT electric switch, which is completely silent in operation and which has no moving parts to wear out, was announced as a new development of the General Electric Company's research laboratory on the occasion of the recent opening in Rockefeller Center of the New York Museum of Science and Industry. About the size of a marble, the "works" of the new switch utilizes the mercury-break principle to function without a suggestion of a click. In the laboratory at Schenectady, one of the mercury switches has turned a 200-watt incandescent lamp on and off some 65 million times in the last two years without failing or wearing out.

The switch consists of two shallow chrome-steel cups about ¾ in. in diameter, sealed together with a strip of lead glass to form a hollow compartment. Separating the cups is a disk of ceramic material in which there is a small hole located near



the edge. The compartment is evacuated after fabrication and in it about four grams of mercury are inserted. The mercury fills roughly one quarter of the space. After insertion of the mercury, the compartment is filled with hydrogen at about atmospheric pressure and sealed off by welding.

In the "off" position, the hole in the ceramic insulating disk is above the line of the enclosed mercury. However, when rotated twenty degrees the switch assumes a position where the mercury can flow through the hole, thus establishing a contact between the two chrome-steel cups and closing the circuit.

Hydrogen is used in the switch because of its properties as a cooling agent and because in it an arc can be better quenched.

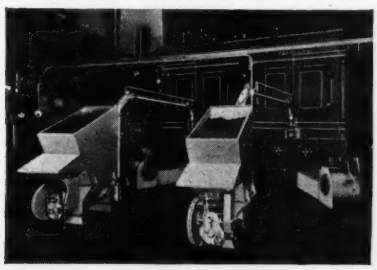
An additional feature of the switch is a tiny plate of steel with two-tenths of a mil of platinum superimposed on its surface. One such plate is welded to the inside of each steel cup, affording better mercury-to-metal contact and keeping the switch from heating. As a final operation in its manufacture, the switch is cadmium-plated to give a good surface for external contact. It is then ready to be fitted into a suitable enclosing case or to be incorporated into any switching operation.

Coal Spreader

IRON FIREMAN MANUFACTURING CO., Portland, Ore., has introduced "Pneumatic Spreader," a stoker designed for inexpensive installation and operation and is adapted to the firing of not only the better steam coals but also the low grade coals which must be burned over a maximum grate area.

Steam size coals are carried into the furnace on a stream of air and to install this stoker, it is only necessary to cut a hole in the boiler front large enough to admit the spreader nozzle.

A feed worm measures the coal and conveys it from bin or hopper base into a transfer box, where it is picked up by the air stream and carried to the nozzle located at a proper angle within the firebox to give even distribution of coal over the grates. The finer particles of coal, which make up a varying proportion of most steam coals, are burned in suspension. Larger pieces are burned in a shallow layer



on the grates, with draft supplied by a secondary fan, in such a manner that the temperature at the grate line is below the fusion point of the ash; the ash, therefore, does not clinker, even with high sulphur coal.

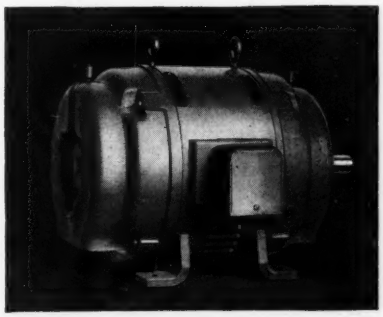
The stoker may be located to suit conditions, usually from 8 to 15 ft. from the boiler front, and even in a separate room. There is no overhead machinery to interfere with firebox cleaning, and the fire doors remain full height.

Iron Fireman Pneumatic Spreader is particularly adapted for installation under boilers of relatively long flame travel, such as horizontal return tubular and water tube boilers, in which efficient combustion of all the coal particles in suspension is assured. Excellent results have been obtained with Scotch Marine boilers. Pneumatic Spreader is available in five sizes, with capacities ranging from 75 to 500 b.hp.

Electric Motors

THE IMPERIAL ELECTRIC COMPANY, Akron, Ohio, announces a line of splash-proof, squirrel-cage motors in all ratings from ½ to 200 hp. for constant and multi-speed, continuous or intermittent duty in all voltages and cycles, for any torque and starting current.

The construction provides protection to the inner parts from splash or spray and yet permits proper ventilation by small openings in the bottom of the end brackets for the air in-take and louvres in the frame cover underneath the motor for the air exit.



Thermometer

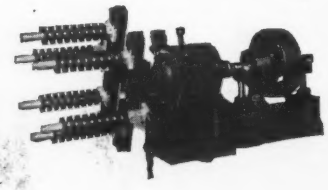
IMPROVEMENTS are announced by The Brown Instrument Co., Philadelphia, Pa., in its portable recording thermometer. The sensitive element has been located where it will respond quickly and accurately to changes in the surrounding temperature. Thus, mounted out in the clear, the mercury-filled bulb is subjected to the natural air currents and the measuring system is in no way affected by the temperature of

the instrument case. The thermometer is built to withstand the rough handling. The metal handle and metal legs are practical and sturdy. The black-enameled, diecast aluminum case is light in weight and corrosion resistant. The completely gasketed door is moisture-proof and the door-in-handle lock is tamper-proof.

Coil Winder

IDEAL COMMUTATOR Dresser Company, Sycamore, Illinois, is bringing out a new, inexpensive Coil Winder Drive, especially developed for use by motor repair shops, industrials, public utilities and others who wind coils. A feature of this unit is the ease of speed control which enables the operator to adjust the output speed to exactly fit his requirements while the machine is running; which is accomplished without loss of time in changing, through a foot lever control. The foot lever control has four functions: starting, stopping, varying speed and automatic braking.

When equipped with a universal type coil winding head, the Ideal coil winder drive winds many different types of coils of different sizes and shapes, such as field,



armature, transformer, motor coils and loops with diamond, round, square or rectangular cores.

An important feature of this new drive is its compactness and ease of speed control. Another feature is that the drive so operates as to maintain a constant tension on the wire being wound. An automatic revolution counter is mounted on the front of the drive, in plain sight, recording exact revolutions of the winding head, irrespective of the direction of rotation. The asbestos lined brake not only holds the wire under tension, but brings the winding head to a complete stop when the foot lever is released. The drive pulley and brake are mounted on a shaft running in babbitted, adjustable self-aligning bearings. The shaft is connected through a flexible coupling to the high speed shaft of the speed reducer.

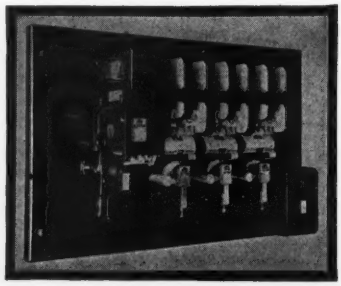
This coil winder drive can be driven from either a line shaft or by a separate motor; and when motor driven, this new drive does not require a special variable speed motor since any standard constant speed motor can be used. The unit has a crackle-baked enamel finish, weighs approximately 108 lb. net and has an input and output speed of 1100 and 200 r.p.m. respectively. The drive pulley is 8 in. in diameter by 2½ in. crown face. Power required to operate is approximately ½ hp.

Motor Starter

ALLIS-CHALMERS MFG. Co. announce a fusible combination across-the-line motor starter just developed at its Condit Electric Manufacturing Division at Boston, Mass. It is designated type A-32DF and is rated 25 h.p. at 440 and 550 v., 15 h.p. at 220 v., and 7½ h.p. at 110 v. The switch consists essentially of a starter unit equipped with totally enclosed temperature overload relays and a fusible motor circuit switch mounted in one case. Some of the features of this starter are: vertical make and break short stroke mechanism; arc prevention principle; self-aligning umbrella-shaped contacts of high thermal absorption type. The starter is sturdy, compact and enclosed in a substantial steel case which is equipped with knockouts for conduit connections.

Circuit Breakers

THE I-T-E CIRCUIT BREAKER Co., Philadelphia, has designed circuit breakers especially for use in the operation and protection of power plant auxiliaries. In effect, the new design is that of a solenoid operated circuit breaker, of high interrupting capacity, combining contactor and motor starter characteristics. The new breakers are of the latched-in type; they do not drop out on loss of voltage.

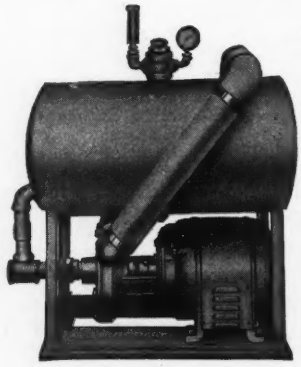


The operating mechanism is unusually rugged to provide for frequent operation. Opening and closing action is extremely fast. The closing mechanism is trip free. Contacts are of special butt type, constructed from non-welding, non-oxidizing alloy. Contact temperature remains low over long periods in closed position. High contact pressure is provided by special laminated alloy springs which carry no current and consequently are not subject to high temperature even during short circuits.

The design is such that standard remote control wiring, 2 or 3 wire, and either momentary contact or maintained contact control, is possible. The new circuit breakers, known as Type K, are small and compact.

Return System

RETURNING CONDENSATE to the boiler at higher temperatures than before is made possible, is claimed, by new equipment manufactured and sold east of the Mississippi River by the American District Steam Co., North Tonawanda, N. Y., and, in the western territory by the Becker Pump Co., Oakland, Calif. Installation of the ADSCO-Becker Condensate and Steam Return System in industrial plants, canneries, dairies, laundries, paper mills and for other processes operating steam consuming drying, cooking and heating equipment is intended to increase production, effect fuel savings and eliminate hotwells, feed pumps, injectors and other accessory equipment. The system is compact, is motor driven, has but one moving part and will return condensate directly to the boiler at any pressure and at temperatures ranging from 275 to 350 deg. F.



New Treasurer

ALLIS-CHALMERS MFG. Co., Milwaukee, Wis., announces the election of Walter E. Hawkinson as Treasurer of the company to succeed the late Raymond

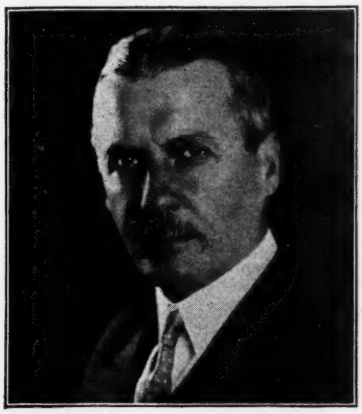
Dill, who died a few weeks ago. Mr. Hawkinson has been with the company for 29 yr. advancing through various positions. Since 1926 he held the post of Assistant Manager of the Tractor Division and prior to that had served 15 yr. in the Treasurer's Department.

Fluid Meters

SCHUTTE & KOERTING Co., 12th and Thompson Sts., Philadelphia, Pa., announce two new types of Rotometers for liquid measurements. One of these has an internal heating tube arranged so that viscous fluids can be held at the required temperature; a second is known as the taper pole Rotameter, intended for metering oils and other semi-opaque liquids. The tapered glass metering tube of the ordinary type is replaced by a tapered pole with the larger end at the bottom. It is said that this meter will handle successfully and indicate the flow of any dark liquid of which a thin film will be translucent.

News From the Field

ALFRED KAUFFMANN was elected president of Link-Belt Co. on March 24, to succeed George P. Torrence, whose resignation as president and director of the company was accepted by the board on the previous day. Mr. Kauffmann started with the company 35 yr. ago as a draftsman. His career has included many responsibilities, such as designing engineer, superintendent of construction, sales engineer, vice-president and manager Link-Belt plant at Philadelphia, vice-president in charge of Link-Belt Dodge and Ewart



plants at Indianapolis, and for the past 4 yr. first vice-president in charge of the company's Chicago plant operations. He was president of the company from 1924 to 1932, and has been a director since 1932. The four board members elected to fill the terms expiring this year are: Wellington Wells, Boston; J. Reece Lewis, Philadelphia; B. A. Gayman, San Francisco; Alfred Kauffmann, Chicago.

ORDERS RECEIVED by the General Electric Co. for the first quarter of 1936 amounted to $59,569,879, compared with $49,379,932 for the corresponding quarter of 1935, an increase of 21 per cent, President Gerard Swope announced recently. This was the largest quarter since the third quarter of 1931.

A. D. HEFFRON, JR., has been appointed District Sales Manager of The Babcock & Wilcox Tube Co. in the Chicago territory, with headquarters in the company's Chicago office, 1502 Marquette Building.

W. R. WOOD, who for 15 yr. was connected with the Chicago office of the Combustion Engineering Corp., as a sales engineer, later with the Whiting Corp. as a combustion engineer in the pulverized fuel division, has joined the Plibrico Jointless Firebrick Co. and will act as a combustion and service engineer.

FOSTER WHEELER CORP. and General Regulator Corp. announce consolidation of the sales departments of the two companies. The distribution of General Regulators will be made hereafter through the branch offices and agents of Foster Wheeler Corp. The sales headquarters of the General Regulator Corp. will be at the general offices of Foster Wheeler Corp., 165 Broadway, New York, N. Y. C. J. King, who has been identified with the General Regulator Corp. since it was organized, will direct this work from New York as in the past.

JUNE 9, 10 and 11, are the days set for the third University of Illinois "short course" on Coal Utilization which will be held on the campus. Prof. A. C. Callen, head of the department of Mining and Metallurgical Engineering which sponsors the meeting, has announced that the purpose of the conference is to present technical and practical information pertaining to coal and its efficient utilization for the benefit of those engaged in mining, preparing, marketing, and using coal, as well as those manufacturing and distributing machinery for the preparation and utilization of coal. Among the speakers on the program are: B. M. Guthrie, of Fairbanks, Morse & Co.; Frank J. Hoke, of Holcomb and Hoke Mfg. Co.; Prof. D. R. Mitchell of the University faculty; L. A. Shipman, of the Southern Coal and Coke Co.; J. G. Worker, of the American Engineering Co.; Prof. E. G. Young of the University; Norvin H. Vaughn, of the Consolidated Coal Co.; Paul D. Hess of Heat Service, Inc.; Prof. A. C. Callen, Prof. D. R. Mitchell, and Prof. M. K. Fahnestock of the University; R. E. Moore, of Bell and Gossett Co., Osborne Monnett, of the Commercial Testing and Engineering Co.; and W. B. Hughes, American Radiator Co.

ANNOUNCEMENT has been made that the business in automatic regulation previously carried on by H. A. Brassert & Co. in the iron and steel industry and by the American Askania Corp. in other industries, has been united and placed in the hands of a newly organized company which is now known as the Askania Regulator Co. This change became effective the first week in March. The offices and the manufacturing plant of the new company remains the same as that of the old American Askania Corporation: 1603 South Michigan Avenue, Chicago, Ill.

REPUBLIC STEEL CORP. has appointed Muir L. Frey to its Metallurgical staff with headquarters at the Republic plant in Buffalo. Mr. Frey comes to Republic from John Deere Tractor Co. in Waterloo, Iowa, where he has held the position of chief metallurgist for the past ten years.

GEORGE L. ERWIN, JR. has been appointed by Crane Co. as assistant to the vice-president in charge of sales. Mr. Erwin was formerly general sales manager of Kearney & Trecker Corp., Milwaukee, and in his newly created position he will develop sales and market research activities.

THE TWELFTH NATIONAL EXPOSITION of Power and Mechanical Engineering will be held from November 30 to December 5 inclusive, coincidental with the annual meeting of the American Society of Mechanical Engineers, according to recent announcement. The exposition is again under the Management of the International Exposition Co. with Charles F. Roth as Manager, at the Grand Central Palace, New York.

R. J. MURPHY, District Representative of the Elgin Softener Corporation, at Pittsburgh, has been promoted to Division Manager with headquarters in the Hippodrome Building, Cleveland. Paul F. Sparrow has been appointed District Representative at Pittsburgh, with headquarters in the Investment Building.

HARRY U. HART, Vice President and Chief Engineer of the Canadian Westinghouse Company Limited, died suddenly at Hamilton, Ontario, on March 15th.

JOINING IN the great interest displayed by the government, farmers and utilities in rural electrification and believing that electricity will be distributed in larger quantities in rural communities, N. G. Symonds, Vice President, Westinghouse Electric and Mfg. Co., has announced the formation of a Rural Electrification Department under the direction of G. A. Sawin.

At the present the department will be represented by two field men, B. P. Hess and R. L. Pleak, both agricultural engineers with wide experience in rural problems.

Mr. Hess will have his headquarters at East Pittsburgh and will cover the eastern and southeastern part of the country. Mr. Pleak will be located in Chicago and will be responsible for the northwestern and southwestern sections. Their entire time will be devoted to promote the use of electricity on farms.

WITH THE FILING with the Secretary of State at Albany of a certificate of change of name recently the Consolidated Gas Co. of New York became the Consolidated Edison Co. of New York, Inc. The change in name, which affects only the parent company of the group of gas and electric companies doing business in New York City and Westchester County, more nearly represents the present nature of the business, which over a period of years had come to be about 75 per cent electric. If a bill now to permit merger of utility companies where at least 95 per cent of the voting stock was owned, and which is now pending in the Legislature becomes a law all the gas and electric companies in the group would be merged into the parent company, which has just attained its new name. The Consolidated Gas Company of New York was formed in November, 1884, as a consolidation of a number of independent New York gas companies.

HILL DIESEL ENGINE CO., Lansing, Mich., has announced the appointment of James M. Degnan as General Sales Manager of the Hill Company effective April 1. Mr. Degnan has been associated with the Worthington Pump & Machinery Corp. for the past ten years, and during the last five of these years he has been Manager of the Multi-V-Drive and Automotive Division.

THE NORTH AMERICAN REFRACTORIES CO., Cleveland, Ohio, announces the acquisition of the silica brick plant and property of the Lavino Refractories Co., formerly owned by E. J. Lavino & Co., located at Womelsdorf, Penn. No other property of E. J. Lavino & Co. is included in this transaction.

J. D. YODER, formerly Vice-President and General Manager of the Cochrane Corp., Philadelphia, Pa., has accepted a sales executive position with The Permutit Co. of New York. For some years past, Mr. Yoder has been interested in the development of hot process treatment of boiler feedwater. He was attracted to The Permutit Co. because of their facilities for conditioning boiler feedwater, and he will continue his interest in the hot process treatment.

As Evidence of activity in the power plant field the American Engineering Co. announces the following orders for Taylor Stokers: Mutual Chemical Co., Baltimore, Maryland, 1; Fisher Body Corp., Detroit, Mich., 3; City of Rochester, Minn., 1, (designed so that coal, oil or gas may be burned in the furnace whenever advisable); Defiance Milk Products Co., Defiance, O., 1; Walter E. Fernald School, Commonwealth of Massachusetts, 1; Chevrolet Motor Co., Indianapolis, Ind., 2; Philadelphia Electric Co. for Willow St. Heating Station, 2; Borough of Vineland, N. J., 1.

The Cooper-Bessemer Corp. has been awarded a contract by the Panhandle Eastern Pipeline Company, of Kansas City, Mo., for twelve 1300 and two 1000-hp. twin-tandem gas-engine-driven compressor units. The engines will pump natural gas from the Texas Panhandle to the city of Detroit.

The present pipe line extends a distance of 1350 mi. to a point north of Indianapolis and will supply the new line being laid by the Columbia Gas & Electric Co. from eastern Indiana to Detroit.

For the Engineer's Library

Mercury Arc Rectifier Practice. By Frederick Charles Orchard. First edition, 5½ by 8½ in. cloth, 224 pages illustrated by halftones and diagrams. Published by Instruments Publishing Co., Pittsburgh, Pa., 1936. Price, $5.00.

In recent years there has been a great increase in the development and application of the mercury arc rectifier, both of the glass bulb and steel tank types, and as a consequence a considerable number of papers and several books have been published on the subject. The literature which follows any new development, generally falls into two classes, first, that devoted to descriptions and statements of elementary principles, and second, that giving the scientific or mathematical principles involved. As pointed out by the author of this book, the first class is of no practical use while the second, though excellent for designers and men of advanced knowledge is of little actual assistance to men who have to install and operate the equipment.

The plant engineer and the operation are not usually assisted by the early literature and too often these engineers make acquaintance with the subject in the hard school of experience.

This is true in the field of the mercury arc rectifier as well as others and it is to bridge the gap between the two classes of literature referred to in the case of the mercury arc rectifier, that the author presents this book. It is a volume intended to help the practical man in the installation, supervision and operation of mercury arc rectifiers. Sufficient theory has been included to enable the reader to apply the practice with a logical understanding. The substation, its choice, layout and allied problems have also been treated from a practical view point. The general interest chapter at the end of the book has been similarly treated and the practical application of the mercury arc rectifieris described and illustrated.

The Townsend Scheme, published by the National Industrial Conference Board, Inc., 247 Park Ave., New York City. Price $1.

This 42-page, paper bound book published in February, 1936, is a report intended only to describe as simply as possible the Townsend plan and how its advocates expected to operate, and to explain how it would actually operate if it were put into effect. The foreword states that the scheme comes in the same family as many other prevalent public policies that are supported by equally erroneous economic principles as will be evident enough in the exposition of the essential ideas involved in the Townsend plan itself.

In Chapter I, under the title of What the Plan Proposes and How It Is Expected to Operate, are given the provisions of the plan, the advantages claimed for the plan and several pages of explanation as to how it is expected to work. The second chapter is entitled How the Plan Would Operate and is divided into four sections, entitled respectively Who Would Be the Pensioners? How Could the Plan Be Administered? Economic Effects of the Scheme, and The Plan and the National Income. The summary is concisely treated in two pages, the final statement being, "The ultimate outcome can only be a general and unmeasurable inflationary rise in prices of goods and services, a reduction in the production of wealth, an expansion in the amount and depreciation of the value of the currency, and a vast redistribution of the national income which will reduce the real income of the whole people and lower the general standard of living."

What Employers Are Doing for Employees, published March 1936, by the National Industrial Conference Board, Inc., 247 Park Ave., New York City. 70 pages, paper bound, price $2.00.

Harold Browne, Chief of the Department of Industrial Management of the Board's Research Staff, has prepared this report to present the results of a survey of the extent and character of the familiar features of modern management in the American enterprise. The work is a compilation of many statistics which have been collected over a number of years by the Conference Board and the present survey brings this statistical record down to date and provides the most extensive picture of the scope and nature of this work so far available.

Chapter I is entitled The Industrial Relations Policy in the United States and treats on the trend of industrial relations policy in recent years and scope of the study. Chapter II is entitled the Industrial Relations Programs in the United States and in this chapter are treated collective bargaining, improving the employee's economic status, employee self-improvement, employee physical welfare, employee privileges, employment technique and prevalence of certain activities in 1927 and in 1935. In the appendix are treated the prevalence of specified personnel activities, classified by industry, size of establishment and geographical location.

Floods in the United States—Magnitude and Frequency by Clarence S. Jarvis and others. 6 by 9 in. 497 pages, paper cover, illustrated with diagram and with numerous large map inserts. United States Department of the Interior, Water Supply Paper 771. For sale by the Superintendent of Documents, Washington, D. C. 1936. Price $1.00.

The quantity of data contained in this book is truly enormous, and to those who need data of this kind, it must be invaluable. From time immemorial floods have transformed beneficient river waters into a menace to humanity, indeed, as we write, the newspapers carry headlines of a new Johnstown Flood and from all over the nation come reports of other serious floods. As pointed out in the foreword of this book, the aggregate direct property damage caused by floods in this country has been estimated roughly to average $35,000,000 a year.

The need for more complete and systematic knowledge of floods was impressed upon the Mississippi Valley Committee early in its consideration of public works projects including river utilization and control. Records now available for over 225 rivers of our country show daily flow for 20 years or longer—a sufficient time to afford reliable information of flood characteristics as a basis for planning. With the necessity already apparent and the data available, this study was undertaken. The objective has been to review the technique and procedure of estimating expected floods and to compile in a form suited to ready reference, flood statistics for streams where long time records are available. The results of this study are presented in this book and constitute a substantial contribution to this end.

Fireless locomotives designed to be charged from stationary boilers are described in a new bulletin just issued by the Heisler Locomotive Works, Erie, Pa.

Bulletins describing crushers and conveyors built by the Jeffrey Mfg. Co., Columbus, Ohio, are described in three new bulletins; 621, single roll crushers; 622, double roll crushers; and 623, portable scraper conveyors.

Five types of Babcock & Wilcox Insulating Firebrick are treated in a new booklet recently released by The Babcock & Wilcox Co., 85 Liberty St., New York City. A table of physical characteristics, curves of thermal conductivity, a list of applications, a typical example of savings in time and fuel costs effected through the use of these insulating firebrick, and illustrated descriptions of the special, lightweight constructions which have been developed should interest those concerned with furnace construction and maintenance.

Air conditioning with Frick equipment is described in two recent publications, one Bulletin No. 506-A of the Frick Co., Waynesboro, Pa., and one entitled Air Conditioning in Baltimore and the South by Paul J. Vincent Co. of Baltimore, Md.

"Seven Facts About Boiler Tubes" is the title of Bulletin T-14 published by The Babcock & Wilcox Tube Co., Beaver Falls, Pa., which explains the effect of the manufacturing process upon the quality of a boiler tube, and answers many other important questions of interest to every buyer or user of boiler tubes.

Sullivan Machinery Co., Michigan City, Ind., is distributing a new bulletin on Unitair compressors which are of the two-stage, single acting, completely air cooled, V-type, incorporating many advanced features in compressor design.

THE LINDE AIR PRODUCTS CO., 30 East 42nd Street, New York City, is distributing a 12-page, illustrated booklet on the technique of oxy-acetylene welding of brass and bronze as employed in ornamental work and the welding of commercial yellow brass pipe. Joint design and welding technique are discussed in detail. Three tables give data on welding time, material consumption, and tensile strength of welds made in various positions.

DIESELS for automotive marine and industrial use are described in a new 28-page bulletin issued by Cummins Engine Company, Columbus, Ind. The bulletin shows typical installations, describes the construction and operation of the engine and the Cummins fuel system.

STOKERS as built by the Chicago Automatic Stoker Co., 14 N. Clinton St., Chicago, Ill., are described in a new bulletin just issued by the company. This stoker consists of a roto motor driven agitator, or distributor reel with blades which may be varied in inclination so as to give proper coal distribution over the grate for different grate areas and draft conditions.

HENRY VOGT MACHINE CO., Louisville, Ky., has recently published a pamphlet dealing with Vogt Class-LE four drum curved tube boilers. The bulletin is unique in that it contains little text material, but is filled with line drawings giving dimensions of various designs of boilers in this class which are installed throughout the country.

COMPARISON OF MUNICIPAL and Company Rates is the title of a recent bulletin published by the Edison Electric Institute, 420 Lexington Ave., New York City. The bulletin contains data and conclusions based on the electric rate survey of the Federal Power Commission with supplementary material on Dr. Warren M. Persons' study of municipal plants, on inaccuracies in the figures of the 1932 census of central light and power stations, and on domestic electric consumption in Canada.

COLLINS WATER TUBE BOILERS as manufactured by the California Steel Products Co., Bay and Taylor Sts., San Francisco, Calif., are described in detail in a 12 p. catalog just issued. These boilers are built in sizes from 96 to 5000 hp. for a range of pressures up to 1200 lb.

A NEW EDITION of its bulletin, "Portable Cable," has been issued by the General Electric Co. This bulletin (GEA-1018A) gives complete data and listings of all types of tellurium all-rubber, Glyptal compound, and braided types of portable cable for mining, welding and transit equipment, electric shovels and dredges, and similar apparatus. Additions since the previous issue of the bulletin include the new loom-sheath and Glyptal compound types; new designs of shielded cable for high-voltage service on shovels and dredges; and new cable connectors, terminals, and couplers.

HIGH VOLTAGE POWER TRANSFORMERS is the subject of an attractive 12 page new bulletin just released by Allis-Chalmers Mfg. Company, Milwaukee, Wis. Fourteen features of design are emphasized, each feature being well illustrated and described.

SMOOTH-ON MFG. CO., Jersey City, N. J., has recently issued another of its handbooks of helpful ideas for engineers dealing with Smooth-On cements and their uses for various purposes about the power plant and home.

W. H. & L. D. BETZ, 235 W. Wyoming Avenue, Philadelphia, Pa., has issued a thirty page booklet giving simple instructions for testing for hardness, alkalinity, chloride, sulfate, dissolved oxygen and pH value according to standard methods. Tetrahydroxyquinone (THQ) and Betz-Hellige methods for sulfate are described. Testing kit and chemicals are cataloged.

NEW CATALOG, No. 1520, has been published by Link-Belt Co., Chicago, on Link-Belt anti-friction bearing units available in streamlined pillow block, hanger, takeup, flanged, duplex and special mountings.

BONNEY FORGE & TOOL WORKS, Allentown, Pa., is distributing a pamphlet dealing with WeldOlets and ThreadOlets which are trade names for fittings used in pipe fabrication. The WeldOlets are convenient in making branch connections such as tees, crosses, side-outlets, etc., by welding. The ThreadOlets, however, are used for similar purposes except that they have their outlets tapped to standard sizes.

D-C TURBINE-GENERATOR sets of from 10 to 400 kw. are described, and their operating advantages enumerated, in a new 4-page folder, Bulletin GEA-2295, published by the General Electric Co., Schenectady, N. Y.

AN ATTRACTIVE 12-PAGE BOOKLET covering the subject of Automatic Production Control has just been issued by Reeves Pulley Co., Columbus, Indiana. This booklet discusses thoroughly the matter of automatic speed regulation of industrial production machines and conveyors. It begins with discussion of the need for automatic control, with examples; tells how automatic regulation is accomplished through use of one of four type of Reeves Controls in connection with the Reeves Variable Speed Transmission; describes these four controls —hydraulic, mechanical, electric and differential—in detail; and tells and shows how they may be connected and used to meet specific requirements in many different industries.

THE LINCOLN ELECTRIC CO. has issued a bulletin under the title "A Guide to Lower Tooling Costs with Shielded Arc Welded Steel Jigs and Fixtures" which gives not only reasons for shielded arc welding and how many industries tool up with this type of equipment, but illustrates the application to many tools and explains how to equip the tool room for shielded arc welding.

A NEW FOLDER issued by Flexrock Co., 800 N. Delaware Ave., Philadelphia, Pa., describes in detail a low cost method of repairing floors in industrial plants by means of Ruggedwear Resurfacer.

GENERAL CHARACTERISTICS as well as specific properties of each of the five B&W Mortars and Plastics are treated in a new booklet by The Babcock & Wilcox Co., 85 Liberty St., New York City. The selection of the correct mortar or plastic for each type of work is simplified by a reference table included in this booklet.

AMERICAN SCHAEFFER & BUDENBERG Division of the Consolidated Ashcroft Hancock Co., Bridgeport, Conn., has recently issued its catalog No. 1359 dealing with American mercury pressure and vacuum gages with special reference to their uses in power houses. The catalog is well illustrated with halftones in color and contains printed descriptions of the various gages manufactured by this company.

THE DAYTON RUBBER MFG. CO., Dayton, Ohio, has recently issued Catalog No. 105 describing the Dayton Cog-Belt Drives. The catalog not only describes the design and manufacture of these belts, but gives tables of specifications for various sizes and horsepowers which these belts will transmit.

THE BRISTOL CO., Waterbury, Conn., is distributing a new thermometer catalog, containing 88 pages of information concerning the theory and practice of modern-day thermometry. This catalog, No. 1250, covers Liquid-Filled, Vapor-Tension, and Gas-Filled Recording, Indicating and Controlling Thermometers. It also describes a new interesting Small-Bulb Gas-Filled Thermometer.

THE DELTA-STAR ELECTRIC COMPANY, Chicago, Illinois, have issued a new two-color 24 page bulletin describing "PM-22" and "PM-23" group operated pole top disconnecting switches in ranges from 7.5 to 161 kv.

Complete engineering data, dimensions, weights, manual and motor operating mechanisms, steel mounting frames and insulator data are given.

RO-TWIN air compressors for pressures up to 100 lb. gage are described and illustrated in a new bulletin, Leaflet 2218, issued by the Allis-Chalmers Mfg. Co., Milwaukee, Wis.

APPLICATIONS of Cameron motor pumps for air conditioning service are covered in a six page bulletin, Form 2200, prepared by the Ingersoll-Rand Co., 11 Broadway, New York, N. Y.

AMONG THE SUBJECTS discussed in a new catalog of Edward non-return valves, designated as 11-B, issued by The Edward Valve & Mfg. Co., Inc., East Chicago, Ind., are selection of the correct size of non-return valves, details of design, the choice of materials, the functions of the Edward Impactor handwheel and the use of welding ends, as well as motor controls.

CONSTRUCTION, installation and operation of the "Zip-Lift" hoist are treated in a new bulletin published by the Harnischfeger Corporation of Milwaukee. This new unit is an electric hoist offered in 250 and 500-lb. capacities.

THE BABCOCK & WILCOX CO., 85 Liberty Street, New York, N. Y., has now ready for distribution a new edition of the booklet featuring the B. & W. Integral-Furnace Boiler which is fully illustrated and contains details of the design and construction of this modern unit, presents typical performance data, and includes photographs of units now installed or on order.

SWITCHES for overhead tramways are described in a new folder issued by the Cleveland Crane & Engineering Co., Wickliffe, Ohio.

TYPE PC CABINETS for Air Conditioning, available in capacities from 3 to 24 t. are described in Bulletin 501 of the Buffalo Forge Co., Buffalo, N. Y. The application of direct expansion coils to air conditioning service is given, with calculations, charts, and temperature tables to assist in solving application problems.

"MERCURY ARC RECTIFIERS for Trolley Bus Service" is the title of a new illustrated Bulletin 1174 issued by Allis-Chalmers Mfg. Company, Milwaukee, Wis. It deals with the application of this type of converting equipment to a rapidly growing field of transportation. The suitability of rectifiers for power supply to trolley bus systems is demonstrated by interesting operating and performance data.

Power Plant Construction News

Alaska, Seward—Municipal Council has increased PWA loan and grant from $118,000 to $166,000, for proposed new municipal hydroelectric power plant, with transmission line to city, recently referred to in these columns, and work is scheduled to begin in near future. Plant installation will include two 375-kv-a. water turbine-generator units. Hubbell & Waller Engineering Corporation, Alaska Building, Seattle, Wash., is consulting engineer.

Ark., Paragould—City Council will soon take bids on revised plans for new municipal electric power plant and electrical distribution system. Fund of $190,000 has been arranged through Federal aid. W. A. Fuller & Co., 2816 Shenandoah Avenue, St. Louis, Mo., are consulting engineers.

Calif., Los Angeles—Hepburn & McTavish, Ltd., 432 Colyton Street, distiller, plans steam power station in connection with new distilling plant at Nadeau and Maie Streets. Entire project will cost about $80,000. Arlos R. Sedgley, 910 North Serrano Avenue, is architect. Work scheduled to begin this spring.

Calif., Oakland—Owens-Illinois Pacific Coast Co., 1855 Folsom Street, San Francisco, Calif., plans power house at new glass-container manufacturing plant on 13-acre tract of land on Fruitvale Avenue, Oakland, recently acquired. Initial works will comprise four main units. Electric power equipment will be installed for operation. Entire project will cost about $1,800,000. Work will begin this spring. Kaj Theill, 580 Market Street, San Francisco, is structural engineer.

Colo., Pueblo—Board of Pueblo County Commissioners, Court House, is considering extensions and improvements in power house in Court House, including installation of two new boiler units and auxiliary equipment.

Conn., Waterbury—Lux Clock Mfg. Co., Johnson Street, plans installation of electric power equipment in new three-story and one-story plant additions, for which bids will be asked soon on general contract. Entire project will cost over $100,000. Henry T. Moeckel, Naugatuck, Conn., is architect.

Ga., Athens—Athens Hosiery Co., recently organized, care of Lockwood, Greene Engineers, Inc., 30 Rockefeller Plaza, New York, N. Y., consulting engineer, plans installation of electric power equipment in new local multistory knitting mill. Work scheduled to begin this spring. Entire project will cost close to $300,000.

Ga., Rossville—Peerless Woolen Mills, Inc., plan installation of electric power equipment in new one and two-story additions to local textile mill. Entire project will cost about $250,000. J. L. Hutcheson is president and treasurer, in charge.

Ill., Chicago—Zenith Radio Corporation, 3620 South Iron Street, manufacturer of radio apparatus, plans installation of electric power equipment in new plant addition, comprising about 100,000 sq. ft. of leased space on same street. Company also plans entirely new plant later in the year. Cost reported over $200,000.

Ind., Hammond—Lever Brothers Co., has plans for new one-story electric generating station in connection with construction of two main building units at local soap works, a finishing unit and processing building, respectively. Electric power equipment will be installed in last noted factories for operation. Entire project will cost close to $500,000. Stone & Webster Engineering Corporation, 49 Federal Street, Boston, Mass., is consulting engineer. Company headquarters are at 164 Broadway, Cambridge, Mass.

Ind., Indianapolis — Indianapolis Brewing Co., New York Street, plans installation of power equipment, mechanical-handling and other equipment in connection with extensions and improvements at brewery. Entire project will cost about $125,000. Carl Frey is secretary and treasurer.

Kan., Kansas City—Board of Public Utilities, City Hall, Charles A. Lowder, secretary, has plans under way for extensions and betterments in municipal electric light and power plant, with installation of new 30,000 kw. turbo-generator unit to increase capacity from 39,000 to 69,000 kw.; 6000-hp. high-pressure boiler and complete auxiliary equipment. Entire project will cost close to $1,500,000. Burns & McDonnell Engineering Co., 107 West Linwood Boulevard, Kansas City, Mo., is consulting engineer.

Ky., Lebanon—The John A. Wathen Distillery Co., Lebanon, plans installation of power equipment in connection with extensions and improvements in plant. A new one-story boiler house will be built. Entire project will cost close to $100,000. William J. Harris is company official in charge.

Mich., Dearborn—Ford Motor Co., plans early construction of new addition to power plant. Cost reported over $300,000, with equipment. Giffels & Vallet, Inc., Marquette Building, Detroit, Mich., is engineer.

Mich., Escanaba—Escanaba Paper Co., has approved plans for extensions and improvements in power plant at local mill, including installation of new turbo-generator unit, high-pressure boiler and auxiliary equipment. Cost estimated close to $150,000.

Minn., Crystal Lake—Common Council has preliminary plans under way for proposed municipal electric light and power plant, using Diesel engine-generating units. Proposed to hold special election soon to approve project and financing. Estimates of cost and other details are being prepared by Power Engineering Co., Metropolitan Life Building, Minneapolis, Minn., consulting engineer.

Mo., Nevada—Missouri State Building Commission, Capitol Building, Jefferson City, Mo., Edgar M. Eagan, executive secretary, plans early call for bids on revised plans for extensions and improvements in power plant at State Hospital No. 3, Nevada. Cost estimated at $192,000, including new equipment to be purchased. Black & Veatch, 4706 Broadway, Kansas City, Mo., are consulting engineers.

Mo., St. Louis—St. Louis Dairy Co., 2000 Pine Street, plans installation of electric power equipment in new two and three-story and basement addition to milk products plant, 100x210 ft. Cost over $200,000. Superstructure will begin soon.

Mont., Shelby — Great Northern Utilities Co., Great Falls, Mont., plans extensions and improvements in power plant at Shelby, including installation of new turbo-generator unit and auxiliary equipment. Cost about $100,000. Donald D. McDowell is engineer in charge of construction.

N. Y., West Point — Constructing Quartermaster, United States Military Academy, will receive bids until May 6 for equipment for local power plant, including one 625-kw. turbo-generator unit with accessories, high-pressure steam boilers, fuel oil storage tanks and other equipment, as per specifications on file.

N. C., Greensboro—Mock, Judson, Voehringer Co., Inc., Howard Street, plans installation of electric power equipment in new addition to hosiery mill. Entire project will cost about $150,000. J. K. Voehringer, Jr., is president, in charge.

N. C., High Point—City Council, E. M. Knox, city manager, is considering plans for large municipal hydroelectric power project, including station on Roanoke River, transmission line to city, power substations and other structures. Entire project will cost close to $7,400,000. Application has been made for Federal grant of about one-half such sum to begin work this spring.

Ohio, Toledo—Department of City Service, 525 Erie .Street, George N. Schoonmaker, director, has rejected bids recently received for extensions and improvements in municipal power station, including installation of equipment, and will ask new bids at early date. H. P. Jones & Co., Second National Bank Building, are consulting engineers.

Ont., Thorold—Ontario Paper Co., Thorold, has plans under way for new hydroelectric generating plant on site on St. Lawrence River, Province of Quebec, recently acquired for new paper mill and townsite. Plant will be equipped for initial capacity of 60,000-hp. Electric power equipment will be installed for mill service. Entire project will cost over $6,000,000.

Ore, Brooks—Labish Cold Storage Co., Ronald E. Jones, Brooks, near Salem, Ore., president, plans new one-story cold storage and precooling plant, 50x160 ft. Cost close to $50,000, including equipment. Proposed to begin work this spring.

Tenn., Knoxville — Swift & Co., Union Stock Yards, Chicago, Ill., plans installation of electric power equipment in new ice cream and dairy products plant on site recently acquired on King Street, Knoxville. Proposed to begin superstructure soon. Entire project will cost about $100,000. Guy Fox is company manager at Knoxville.

Wash, Aberdeen—West Coast Plywood Co., Becker Building, plans new boiler. plant at proposed local mill Work will begin soon. Entire project reported to cost close to $100,000. Clarence W. George, Becker Building, is architect.